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ABSTRACT

Primarily intended for instructors but also useful to students, this guide provides a set of lessons (interlaced with humorous phrases and cartoons) for teaching fundamental information for the building trades. Each lesson contains objectives, related information, and a review or summary. Unit I is a brief, humorous message to the student on the advantages of learning about the building industry. Other units cover the areas of: (1) Plans (6 lessons), (2) Excavation (4 lessons), (3) Masonry (15 lessons), (4) Frame Construction (16 lessons), (5) Plumbing (11 lessons), (6) Heating and Cooling (11 lessons), (7) Electricity (11 lessons), (8) Painting (5 lessons), (9) Wall and Floor Coverings (5 lessons), (10) Sheet Metal (4 lessons), (11) Ventilation (4 lessons), and (12) Insect Control (2 lessons). (HD)

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State of New Jersey
Department of Education
Division of Vocational Education

BACKGROUND FOR BUILDERS

-RELATED SCIENCE AND TRADE INFORMATION FOR THE BUILDING TRADES

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UNIT I

A Message from Professor Kool Rock

This pack of science lessons is written and dedicated to the forgotten persons called students. That's right, *forgotten persons* – because everybody keeps saying that school should be fun, but nobody does anything about it.

Well, this pack of lessons is different, because it goes easy on the science facts by throwing in some fiction, humor, and cartoons. Don't let this mixture shake your tree, because whether you are an A, B, or C student – or just a friendly guest – you will be able to separate the facts from the fiction.

There is always a small, vicious group of persons who are "agin" book-learning and who like to burn books. These are the folks that say "O.K, it's different – but who needs it?" Well, you book-burning smart alecks, let me tell you who needs it.

Everybody needs it! The building industry is the largest single industry in the United States and employs more persons than any other. The Building Industry involves the mining, manufacturing, and processing of every product under the sun. Advertising, product sales, real estate, manufacturing, distribution, transportation, and you name it – depend directly or indirectly on the building industry. Thus, your chances of being employed directly or indirectly in the building industry are excellent. So the folks that knock it lack some smarts.

What's the largest single investment that you will probably make in your lifetime? A heap of metal with four on the floor? Wrong. You can snap up a car by trading a few seashells, bottle caps, or a used guitar. Your very own pad will probably start at $30,000 – and by the time you reach the last lesson, inflation may change it to $40,000.

Suppose you never buy, build, or live in a house or apartment, but you prefer caves – can you still use the science lessons? Yup, you will still need science to heat your cave, supply power for your electric guitar, provide lights so you won't step on a snake, and even pump water. Even if you don't drink water, you will need at least a few drops to unglue your eyelids – so you can dodge the bats. You say that you're still not convinced?

Well, read the lessons anyway. How can you intelligently hate something you don't really know about? There is nothing worse than a person who hates something without a good cause. Remember that everybody today needs a cause. So if you ain't got a good cause, use this handy package.

(P.S. You really didn't expect a pack of lessons on cave-building – did ya?)

Signed –
Professor Kool Rock

Professor Kool-Rock

UNIT II – PLANS

Importance of Planning – Ten Important Factors **Lesson 1(A)**

Objective:

At the end of this lesson the student will understand ten important factors in planning to build a house.

Related Information:

Many, many years ago, before shoes and sneakers were invented, nobody worried about planning to build a house. Finding a cave to hide in was the big thing before some dinosaur or monster snapped you up.

Then science stepped in and underarm deodorants and mo..ster repellents came on the scene. Now, m.. could safely leave his cave and really plan his pad. That's what this lesson is all about –– planning a pad.

The best piece of advice in planning a house is to have a notebook and keep a record of "do's" and "don'ts". The following are some important questions you should consider in planning a house.

Why should persons called students be concerned about planning a house? Because . . . .some day you're going to break out of this high school, and you have to plan your escape. Furthermore, students in the building trades should be smarter than other people when it comes to planning houses, because houses are like bread and butter to them, or maybe meat and potatoes.

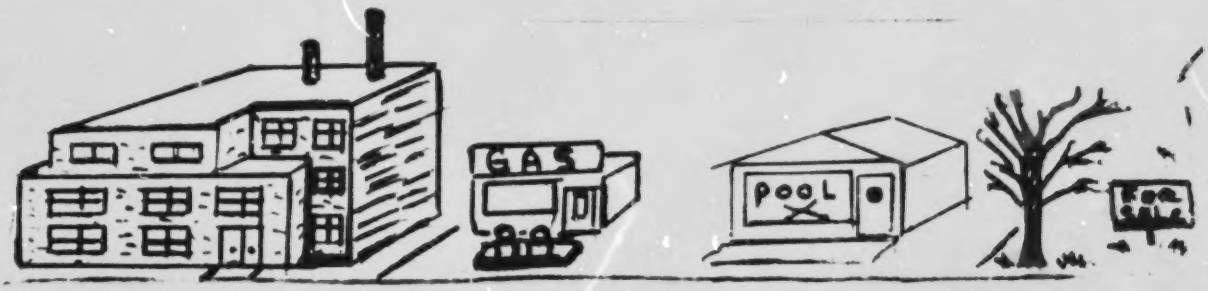
HOW MUCH MONEY DO YOU MAKE?

1. **Money.** What can a guy and gal afford to spend in cash and in mortgage payments? In other words, how much "loot" is there in the bank or under the rug? How much do they earn and what are their current expenses?

2. **Transportation.** Is public transportation available and reasonable in cost? Will transportation be convenient to work, school, shopping, recreation, etc?

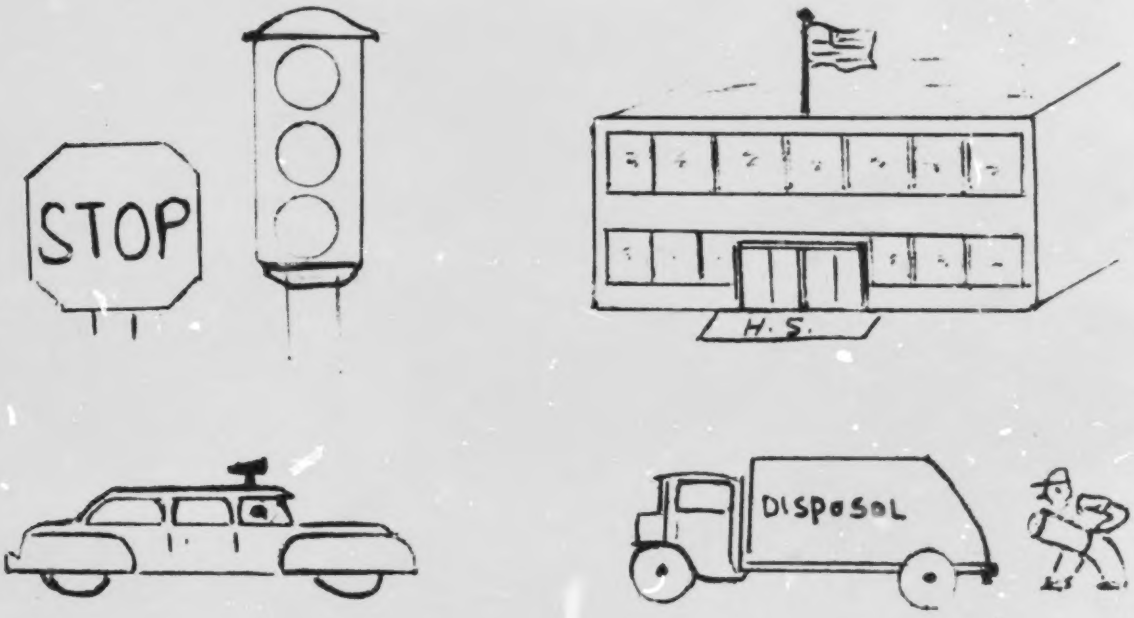
3. **Employment.** Is the area conveniently located with an ample supply of job opportunities? Suppose the owner changes jobs?

4. **Utilities.** Are water, gas, sewers and electricity available? Lack of utilities can be expensive initially or later when they become available. Homeowners are frequently assessed for such improvements as roads, sewers, sidewalks, and curbs, etc. For example, a tiny thing such as the distance between the house and the nearest fire hydrant or firehouse can increase insurance rates.



5. **Characteristics of the neighborhood.** Consider the future as well as the present character of the neighborhood. The actual construction costs are about the same, whether in a cheap site or a top residential area. Most communities are *zoned* – not only for residential, commercial, and industrial areas, but also for *quality grades*. Watch out for areas that lack zoning. You might find out the next-door neighbor will be a factory, gas station, pool parlor or – the worst of all –– a school!

6. **Drainage.** Is the site selected in an area with a high water table or subject to frequent flooding? Floods can do tremendous damage in residential areas. Pick the wrong spot and the home-owner will be raising mosquitoes, frogs, lizards, and other varieties of fish bait in the cellar or backyard.



7. **Taxes.** Will the taxes provide such benefits as good police and fire protection, schools, recreation, refuse disposal, etc.? Remember, an initially low tax rate may later turn out to be high when these services are added.

8. **Economy of design.** Does the plan consider standard-size units, and will it be designed to minimize waste? Will room arrangement consider economy in plumbing and heating? And how about maintenance costs and provisions for future expansion?

9. **Pollution.** What safety or health hazards exist or might arise in the future? Pollution of air and water are real threats in modern living.

10. **Resale value.** Will the design be too modernistic, fancy, or "different" to a point that selling the house would be difficult? "Overbuilding" is a frequent mistake, especially in a poor location.

Assignment

The following are 10 important areas that are important to planning a house. They are worth remembering. Take this checklist and neatly enter it in your notebook. Add any interesting notes that result from class discussion.

1. Money
2. Transportation
3. Employment
4. Utilities
5. Character of Neighborhood
6. Drainage
7. Taxes
8. Economy of Design
9. Pollution
10. Resale value

UNIT II – PLANS

Importance of Planning – Basic Needs **Lesson 1(B)**

Objectives:

1. At the end of this lesson the student will understand that planning should first consider the four basic needs of all people.

2. The student will also realize that planning must be personalized to fit a person's way of living.

Related Information:

Students have only two big problems when they are in school – getting a driver's license, and buying their first heap. Now, how about planning for your future? Some day you will graduate, and get out into the real world of work and play. Whether or not you go into the construction field, you need to know about housing. Not everyone builds houses, but most people live in them. So perk up and pay attention.

Building a home is one of the most important things a person does in his lifetime. It represents probably the biggest investment a person will ever make, and so it requires careful planning.

In plain talk, it is not a snap decision, like buying four wheels with bucket seats at some used car lot. Buying a "four-wheeled mistake" is no sweat. All you have to do is buy some wax, new wheel covers, and floor mats, and then sell it to your best friend.

Mistakes in building can be mighty expensive, and so planning might require several months or even a year. In planning it is advisable to use the professional services of a realtor, surveyor, architect, lawyer, banker, and building contractor.

Another good source of help can come through family, friends, and neighbors, based on personal experience. These non-professionals should not be overlooked, as you can profit by their mistakes.

First, your design or layout should consider the basic needs that everyone has. What are basic needs? To answer this question let us examine your daily routine.

1. You eat . . . . . you need a cooking and eating area.
2. You sleep . . . . . you need sleeping quarters.
3. You relax . . . . . you need a living, family, or recreation room.
4. You keep clean . . . . . you need a bathroom.

Your planning must also consider the number of present and future occupants. Thus, privacy, convenience, and traffic patterns should be planned. Why plan traffic patterns? Well, suppose you have a house full of kinfolk, two big dogs, and a visiting fat friend, and some fool yells "lunch is ready." A guy could get bitten, crushed, or stomped to death without a well-planned traffic pattern. Thus, planning should go beyond your basic needs, depending on your life style.

Lot Survey **Lesson 2**

Objectives:

1. At the end of this lesson the student will understand what is meant by a lot survey.

2. The student will also learn how important a lot survey is from a legal point of view.

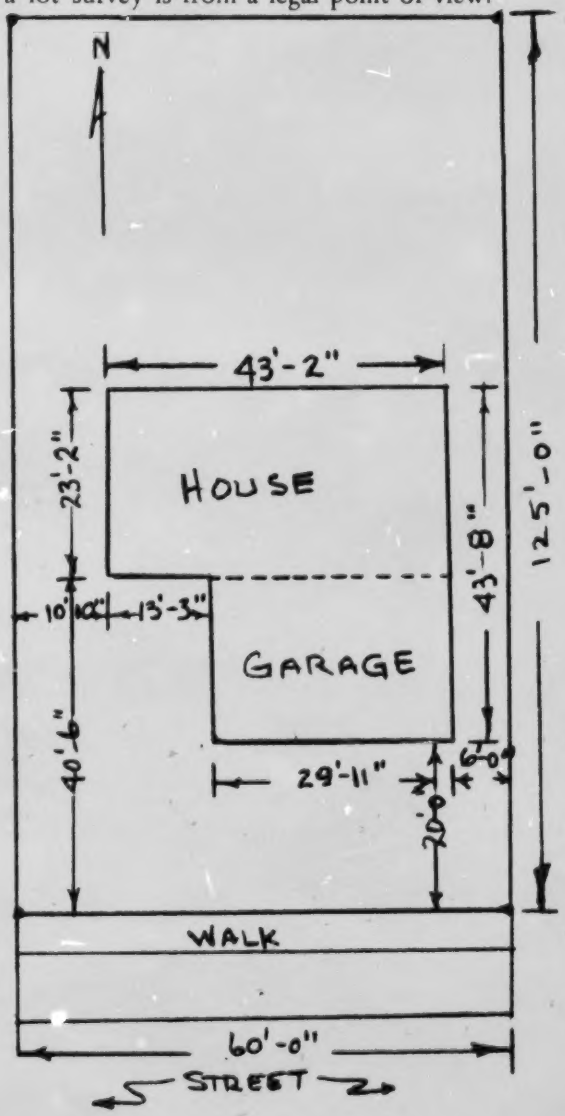
Related Information:

A lot survey is a top-view drawing of a given lot, drawn to scale on a piece of paper. Thus a lot survey is really a birds-eye view of what the lot looks like.

This drawing is prepared by a registered land surveyor or civil engineer, based on recorded surveying facts, plus on-the-spot measuring of angles and distances.

The lot survey shows the boundary lines and land characteristics, such as exact shape, size, and contour of land. Any trees, brooks, utility lines, or other land characteristics are included. The surveyor must also check legal descriptions and make necessary corrections. He then certifies the survey as to its accuracy.

There are three mighty important reasons for an accurate lot survey. It acts as a guide in placing the *right house* on the *right spot* on the *right lot.* Without a certified lot survey you could waste "lots" of time and "lots" of money.



Plot Plan
B. Slick - 46 Easy St., Fuddsville, N.J.
Scale 1"=20'-0"
A. Crook, Architect

The lot survey has the following important uses . . . so fix your eyeballs on them hard.

1. A survey prevents costly legal problems in the future.
2. Banks and mortgage companies require a certified lot survey before *authorizing* a loan of money to build the house.
3. Building inspectors require a certified lot survey before issuing a permit to build the house.
4. The architect needs a lot survey to place your building on the most advantageous place in the lot that still conforms to street set-back and side-line requirements of the zoning laws of the community.
5. The builder needs a survey to guide his workmen and to use as a check on the accuracy of his work.

UNIT II – PLANS

Building Codes – Definition and Purpose Lesson 3 (A)

Objectives:

At the end of this lesson the student will understand

1. what building codes are;
2. the purpose of establishing building codes.

Related Information:

In the beginning, when everybody lived in caves or trees, building codes had only two requirements, and the enforcement was spotty at that. The building inspectors were mainly concerned in spot-checking your cave for winged bats and poison mushrooms. Thus the cave code was uptight on two key points: (1) that all cave entrances be tightly fitted with aluminum combination doors to keep out winged bats; (2) that all cave floors be covered from wall to wall with grass sod or inlaid moss to discourage mushroom growth.

Early Building Inspectors inspected only for Bats and poison mushrooms.

Then some whiz invented shoes out of tough-eating animal hides, and people stomped out of their caves in droves. They wandered to points west like Point Pleasant, Dallas, San Francisco, and other barren wastelands that were completely void of caves. Now they had to build on top of the ground, and they started crowding log cabins and split-levels in reckless abandon. That did it! Congressmen got steamed and added building codes to the bottom of the Constitution, and now we are stuck with them. Now, let's get serious and answer two questions on building codes so that we can pass the course.

1. *What is a building code?*

   Answer –
   A building code is a set of written rules and regulations that control the methods of construction and materials. It sets forth the rules that determine the size, shape, and composition of materials, plus accepted methods of construction at all stages. The code specifies the size and spacing of framing members and all the materials attached. The code presents a *minimum* standard for all houses in the community; however, you may exceed the standards or improve the quality.

2. *Why does a community enact a building code?*

   Answer –
   Without specific rules and regulations, the health, safety, and beauty of a community could never be controlled. Thus, early in the organization of a community, a group of citizens is selected to establish rules and regulations.* The local officials establish the code guidelines and from time to time review any additions or deletions proposed to improve the code. Then they incorporate any changes into the local law.

Even though they are at times burdensome, these rules and regulations are designed to serve the best interests of the majority and to promote the general welfare.

The code sets standards for fire prevention, ventilation, and sanitation by stating safe and accepted practices. Thus, electrical, plumbing, heating, and structural work must conform or the construction will be stopped and violations prosecuted by law.

Minimum lot sizes, setbacks of houses from the street, sideline and backyard minimums, and the uses of various buildings are set forth in the community's zoning ordinances, and must also be observed in every respect.

* In many states a state building code is used as a model.

Building Codes – Enforcement and Assistance **Lesson 3(B)**

Objectives:

At the end of this lesson the student will understand

1. who enforces a building code;
2. how to get assistance with questions concerning the code.

No. 5763 _____ 19___

FLEABURG TOWNSHIP

CANINE COUNTY, NEW JERSEY

BUILDING PERMIT

Permission is granted to _____

_____

at _____ Lot No _____ Block No _____

Nature of proposed work _____

Total Sq. Ft. _____

_____ Zone _____ as per Application

and Ordinance _____

$ _____ $ _____ _____

Fee Estimated Cost Building Inspector

IMPORTANT NOTICE

INTERPRETATION OF FLEABURG TOWNSHIP ZONING ORDINANCE
"SECTION XI–I," CERTIFICATE OF OCCUPANCY

When the building for which this permit has been issued is completed and BEFORE it is used or occupied, you are REQUIRED to have it inspected by the Building Inspector, who will issue a Certificate of Occupancy certifying that the building has been constructed in accordance with the requirements of the Zoning Ordinance and in compliance with the plans and specifications submitted with your application for this permit.

Failure to comply will subject you to prosecution for a Violation of the Zoning Ordinance.

WHEN YOU COMPLETE THE BUILDING FOR WHICH THIS PERMIT HAS BEEN ISSUED *NOTIFY THE BUILDING INSPECTOR.* (Call or Write)

Related Information:

3. *Who enforces the building code*

Answer –
The community employs a building inspector whose duties are inspection and enforcement of the zoning and building codes. The inspector reviews all plans, authorizes construction, issues a permit, and makes field inspections. If he discovers any work that is in violation in any way, he stops the construction.

The inspector must be furnished with the plot plan, a set of blueprints, the specifications, and an estimated cost of construction. Once satisfied that the application conforms to all legal requirements, the inspector collects a permit fee and issues a permit

In many communities inspectors make four field inspections. The construction must meet with his approval at each inspection before you may proceed to the next step. A plumbing and electrical inspector are also employed; they inspect and approve of work in their respective fields.

First inspection: When excavation is complete and the forms are ready for the concrete, an inspection is made. Approval is based on the size, location, and proper installation of the forms prior to pouring concrete. At a later point, a certified copy of the quality of the concrete delivered must be filed.

Second inspection is usually made when all the framing is complete and the rough stages of plumbing and electrical work have been inspected and approved. Normally these two trade inspectors affix an inspection sticker, which the building inspector checks. If framing and electrical work and plumbing are all satisfactory, a sticker is issued, and the walls may be insulated and enclosed.

Third inspection: This inspection is frequently made at random to spot-check materials and construction methods for violations.

Fourth inspection: This is the final inspection before an occupancy permit is issued. This inspection requires that all plumbing, electrical, and utility connections are made and are satisfactory. In some area, such items as sidewalks, driveway, landscaping, and decoration must also be completed.

Note: "Utilities", as used above, refers to water supply. sewer or septic connections, and gas and electrical tie-ins.

4. *Who can explain the building code to you and help you to understand it?*

Answer –

The building inspector is an excellent source, but one seldom used. People feel that he is just another policeman put in their path to say "No, No." Forget it ... the inspector can be your best friend, so by all means seek him out.

A licensed architect is one of the best qualified by training and experience, but he is frequently too busy for petty questions. The builder is also well qualified, but not all builders are cooperative. Seek the advice of more than one builder. You're sure to find a nice, friendly, ex-vocational school product.

Last, but not least, is your old buddy the teacher. Although your teacher may be your best friend, don't drive him crazy with questions because his advice is free. Use the local library and the building department for technical questions.

Above all, be fearless . . . grab all the free information you can get. Put facts into your notebook. After all, your skull can hold only so much.

Building Codes – Violations **Lesson 3 (C)**

Objective:

At the end of this lesson the student will realize that building code violations can be expensive.

Related Information:

5. *Can building code violations be expensive?*

Answer –
You can bet your flea collar and grass skirt it can. The following is a true story, so judge for yourself.

A certain builder had just completed two homes and requested a final inspection to obtain his occupancy permits. The inspector arrived as requested and during his inspection noticed from the grade markings that the roof plyscore was an unapproved type––a sure violation.

To correct the violation, it would be necessary to remove all the roof shingles, tar paper, flashing, and plyscore, to the last piece.

The builder tried to plead his case, but the officials refused to budge. Thus, the builder had one of two choices: rip off and replace the entire roof, or fight his case in court. The builder decided to comply with the code and avoid costly delays and legal expenses. The complete changeover cost the builder about $3000 plus some delay.

The builder did not intentionally violate the code; it was just an oversight on his part. The building code had been changed to read "exterior-type plywood" only two years previously, when the code was updated. How was the builder supposed to know? It's the builder's responsibility to know the code and be alert to code changes. The code should have been checked prior to construction. Ignorance is no excuse.

Could something like this ever happen to you, your paw, or kinfolk? You can bet your sweaty headband and corroded beads it can. So stay alert and keep notes. You will avoid ripping plywood off your tree-house, barn, or home.

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Building Codes – Quiz Lesson 3 (D)

Assignment instructions:

A. Answer these questions correctly and you're sure to drive big cars with four on the floor and smoke expensive cigars.

B. Don't answer these questions and you will spend the rest of your life hiding in the tall swamp weeds when the building inspector calls.

1. Is the building code a written set of rules and regulations that never change? (Explain your answer).

2. Who determines what the rules and regulations of the building code should be?

3. Why are building codes legal requirements that are enforced?

4. If a building code seems burdensome, what are the reasons for the provisions that may seem unfair to the builder?

5. In what ways does the building code protect your health?

6. What does the building inspector require before issuing a permit?

7. What is an occupancy permit, and why is it necessary?

8. When are building inspections made?

9. Name all the sources you know of for getting help with the building code.

10. How can violations be expensive? Can you cite an example from your own experience or from the experience of someone you know?

Blueprints – How They Are Made **Lesson 4 (A)**

Objective:

At the end of this lesson the student will understand how blueprints are made.

Related Information:

Once the preliminary planning is completed, the architect assembles all the information and ideas and makes a master drawing. The master drawing is usually made in black India Ink on transparent linen cloth.

This drawing shows, in picture form, the details, dimensions, materials, and style that reflect all the items the owner has planned. The original drawing is too valuable to give away. It is needed to make numerous copies for the many tradesmen who will use it. It is kept as a copy *master.*

Copies are made by using a special paper which is chemically treated to be sensitive to light. The master tracing and the sensitized print paper are placed together in a frame and are exposed to a bright light. Then after a specific time exposure to light, the sensitized paper is removed and thoroughly rinsed with water.

If properly processed, the coated surface of the sensitized paper will be a clear, deep blue. The drawing lines will come out white against the blue background.

Summary:

Blueprints are used because:

1. The original master can be kept intact and filed for future reference.
2. Copies by this method are fairly inexpensive to reproduce.
3. Copies are easy to produce in large quantities.

Note: Blueprints are also called *working drawings.* Both terms are correct and acceptable.

Research Project:

There are two other methods of reproduction that use chemicals. Research them in your school or local library and prepare a short report on each.

Blueprints – Drawing to Scale **Lesson 4 (B)**

Objective:

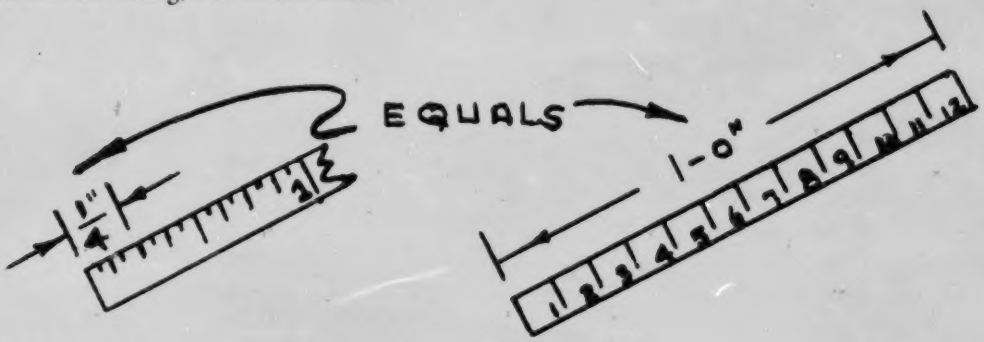
At the end of this lesson the student will understand the term "scale" and how it is used to draw and read blueprints.

Related Information:

Maybe it was a caveman who first said, "A picture is worth a thousand words." How true it is. The caveman wasn't much for words, but his drawings on cave walls were things to behold.

Well, that's what this lesson is all about . . . lines or drawings that "talk." That's right. Drawing is a language that explains things with pictures. Thus, blueprints or drawings are used to give workmen a picture of what the finished house should look like.

Full-sized drawings of a house would be expensive, impractical, and virtually impossible to draw. An architect, therefore, makes drawings to scale. "To scale" means drawn to a smaller size that is easier to draw and handle. For example, many trains, cars, and planes are drawn *to scale* and made in *scale* models. The scale model is exact in every detail to the real-life thing, but much smaller.



¼" Scale

In house drawings, one foot is usually used as the basis of the scale. Thus, a house drawing is often made so that every ¼" of length on the drawing is equal to 1 foot on the actual building (¼" = 1 foot). This means that every dimension of the house, be it length, width, wall thickness, or window, when measured with a ruler can be converted into feet.

Drawings made to a ¼" scale are convenient and easy for tradesmen to read, since most tradesmen use a carpenter's ruler. In special cases where the buildings are very large, it may be necessary to draw blueprints to a 1/8" scale. In any case, a blueprint will always indicate the scale to which it was drawn.

Detail drawings are frequently added to show an enlarged view of a complicated part. A 1½" scale is frequently used for these. Thus, if 1½" equals one foot, a line that is 3" long would represent two feet. Got it?

All blueprint drawings, regardless of what scale is used, must be exact to the last inch, because an error in the drawing would create an error in the construction of that building.

Learning to read blueprints is easy——all you need are some old blueprints to mess with. Get your dedicated teacher to get some. Any old prints by George Washington's grandfather would be worthless; anything from the Civil War on would be fine.

The Story of How Blueprints Were (Not) Invented — Lesson 4 (C)

Objective:

This is a lesson primarily designed to relax students and give them a change of pace.

Un-related Information:

The following information will take you on a sneaky trip back through the moldy pages of history. To explain the history of working drawings, the entire story is based on fiction and an assorted pack of lies.

Once upon a time everybody, including teachers, lived in caves and there was no demand for buildings or plans. These cavepersons were a simple and happy lot until their kids started to hot-rod and drag their rock carts. These wild kids started "burning" their rock wheels and kicking up heaps of dust that made the eyes of the "old rock snappers" smart something fierce.

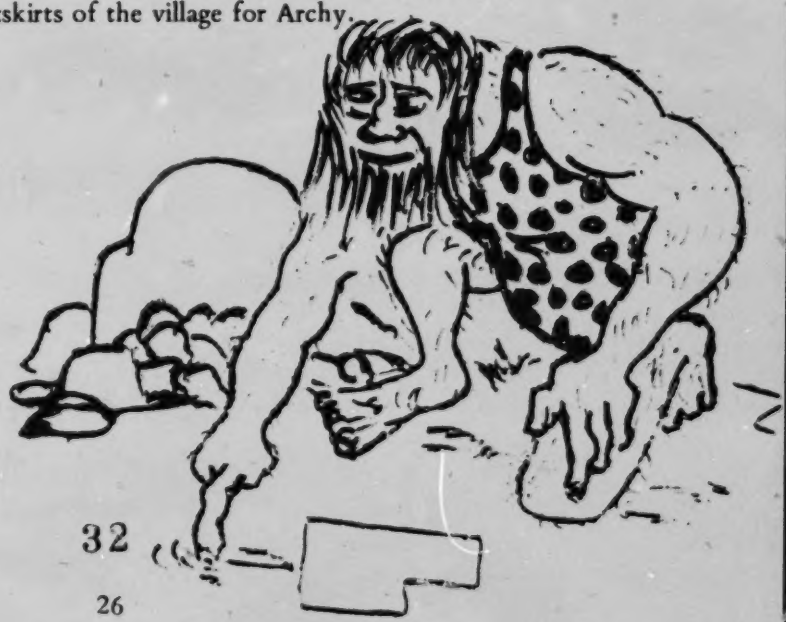
Well, that did it. There was a big generation gap even in those days, and so the old rock snappers called a secret meeting to scheme out the problem.

The meeting actually turned out to be history's first recorded conspiracy against kids. At the meeting, the snappers decided to build a vocational high school, so they could get their kids off the dusty streets.

The cave folks started the first building in history, and folks were piling up rocks everywhere. The rock piling really "got" crazy––you might say that some of the folks "got" carried away––because that's what really happened.

Then out of the confusion a shrill voice shouted, "Stop! We need a plan before we kill ourselves!" Then another voice shrieked, "Let's get Archy to draw something." The cave crowd seized on this beautiful idea and shouted in a chorus "Oh! Joy". Then they promptly sent a runner to the outskirts of the village for Archy.

Archy Tect was a poor village artist who needed work badly, and so he accepted the offer quickly (mainly so that he could eat again). As soon as Archy appeared on the scene, he squatted on the dusty sand and started to make groovy signs in the sand with his big finger. The crowd became excited and started to scream and stomp with every groove . . . and so the first working drawing began.



The pushing and the stomping finally got out of hand, and Archy's drawing was messed up time and time again. Then to make matters stickier, a rock fight started up in full swing.

Rocks were flying all over the place, when suddenly a stray rock bounced off of Archy's skull. Archy promptly assumed a flat position, face down, pointing in a position of north by northeast.

This "rock festival" was really getting out of hand, when just in the nick of time a slick young chick saved the day. The cool chick stomped out of a big cool cave and shouted, "Stop it ... Let me show you folks the way out." Then quick as a wink this gal whips out an eyebrow pencil, leans over Archy, and starts to draw the floor plan on Archy's back. At last the cave folks had a permanent, portable working drawing that could withstand a lot of stomping.

Archy, naturally, took a mighty dim view of lying face down until the school was finished. But a few well-placed rocks made Archy cooperative. However, a bad case of sunburn on Archy's back resulted in switching to animal skins, and finally to composition paper.

Finally the school was finished, and the "young rocks" started to learn all kinds of trades. Rock-carving, rock-throwing, and rock-painting became the backbone of the curriculum, and soon many other courses were added. The old rockers went back to chasing dinosaurs, lizards, and lions, and Archy Tect became famous as a cave- and school-designer.

The whole deal wound up on a happy note, because Archy finally won the cool chick's hand and everybody lived happily ever after – except the students and the principal.

The principal's main beef was that Archy left out the teacher's lounge, detention room, and a maximum security spot for the real rough rocks. The principal claimed that Archy must have been stoned to come up with such poor "working drawings."

Blueprints – General Functions Lesson 4 (D)

Objective:

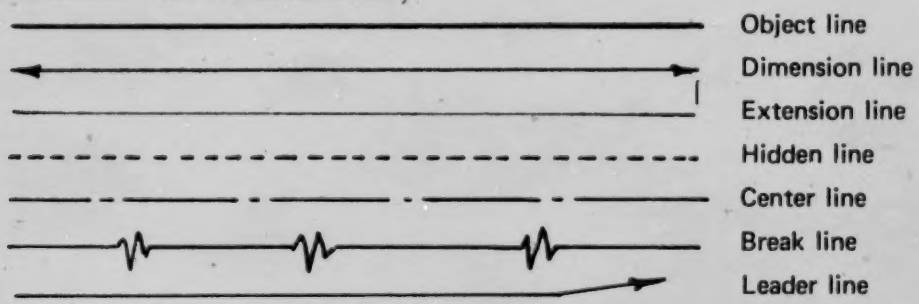
At the end of this lesson the student will understand the functions of blueprints in house construction.

Related Information:

Working drawings are pictures of a proposed house that clearly show you all top, side, and cross-section views. They give the design, details, dimensions, and materials to be used.

These drawings use a simple, basic language of lines and symbols that tell a construction story. Imagine that . . . a drawing language that can be understood *anywhere* in the United States and, with a few minor changes, *anywhere* in the world!

Let's use a simple comparison. You can build countless words in the English language by using the alphabet; in working drawings you "build" all sorts of objects by using an alphabet of lines. The tradesmen in construction learn this special alphabet and can communicate with one another easily.



Alphabet of Lines

Thus a blueprint or working drawing can supply all the information necessary to build anything from a dog house to a skyscraper.

Remember that blueprints are the end result of a great deal of preliminary work. The final drawings have to consider income, availability of utilities, basic and personal needs, zoning, and even weather.

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UNIT II – PLANS

Blueprints – Specific Functions **Lesson 4(E)**

Objective:

At the end of this lesson the student will understand the specific functions of blueprints.

Related Information:

To be considered complete, good blueprints should cover the following areas.

1. **Lot plan.** – This is a drawing that shows the top view of the lot. The drawing uses a scale and dimensions, just as the main drawings do. It shows the boundary lines of the lot and gives the exact location of the house on the lot. The drawing is drawn to the owner's preference, but must conform to building and zoning codes.

2. **Floor plans.** – These drawings usually consist of three plans: (1) masonry, (2) first floor, (3) second floor. This gives the workman a top or birdseye view of each level.

3. **Elevations.** – These drawings show the outside view of all exterior walls in the same scale as the floor plans, and they are usually labeled: (1) front elevation, (2) rear elevation, (3) right side elevation, (4) left side elevation.

4. **Details.** – Detail drawings are blown up or enlarged views of certain parts of a house in a larger scale than the main plan. This enlargement is necessary for accuracy and clear perception.

5. **Section views.** – A section view is a cutaway view exposing a particular area of construction to a clearer view. It gives an accurate idea of the size, shape, and materials involved.

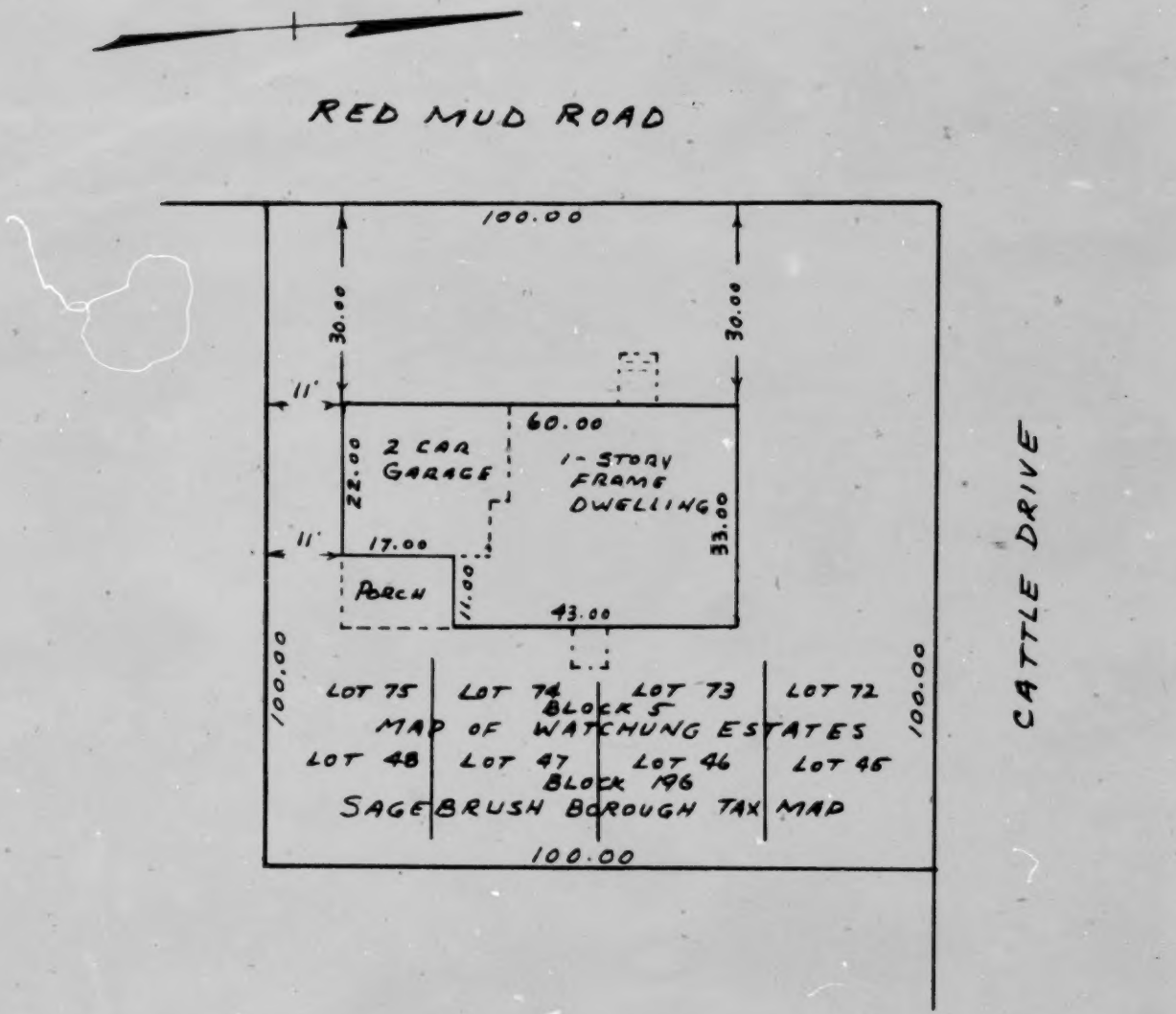
   Imagine how hard it would be to explain what a watermelon is like to an Eskimo. However, if you cut the watermelon in half (cutaway view), then the texture, moisture, seeds, and rind would present a clear picture. Well, that's what section views do—they give you a clear picture.

6. **Roof plan.** – This plan shows the roof framing detail and is especially helpful when framing is complicated.

7. **Electrical plan.** – This shows the proposed location of all switches, outlets, appliances, power panel, etc.

SURVEY FOR WILLIE & MILLIE HOMESTEADER
LOCATED IN BOROUGH OF SAGEBRUSH
CACTUS COUNTY, TEXAS

BUTCH CASSIDY
ENGINEER
4½ MAIN ST. GULCH CITY
DATE DEC. 1, 1849



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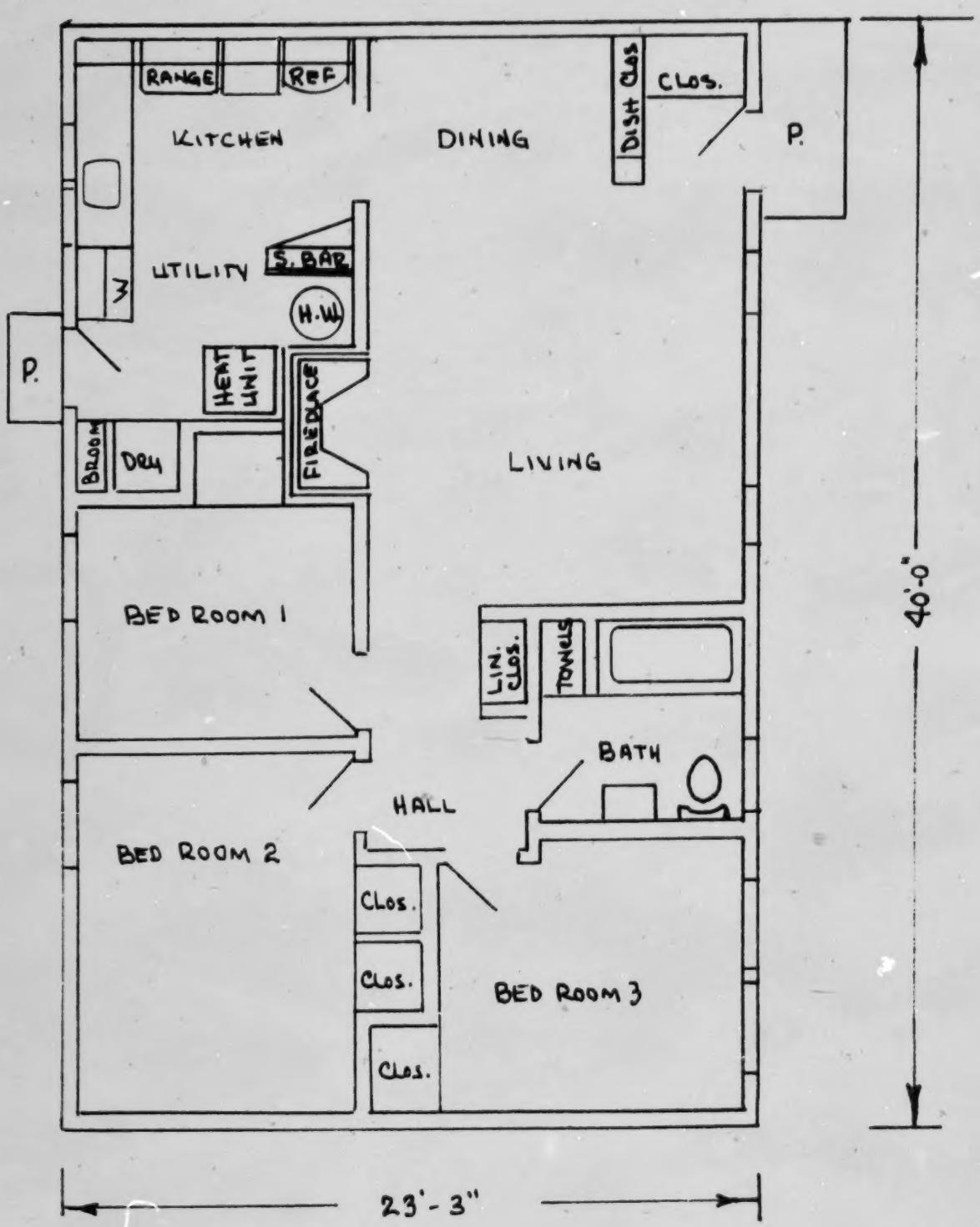
8. **Heating plan.** – This plan shows the type, location, and size of the heating system, plus other important installation details.

9. **Plumbing plan.** – This plan shows the location of plumbing fixtures in the kitchen, bath, basement, or utility room. It usually shows some details of the septic or sewer connection.


RANGE
REF
KITCHEN
DINING
DISH CLOS.
CLOS.
P.
UTILITY
S. BAR
W
H.W
HEAT UNIT
FIREPLACE
P.
BROOM
DRY
LIVING
BED ROOM 1
LIN. CLOS.
TOWELS
BATH
HALL
BED ROOM 2
CLOS.
CLOS.
BED ROOM 3
CLOS.
40'-0"
23'-3"

FLOOR PLAN

The Role of the Architect Lesson 4 (F)

Objective:

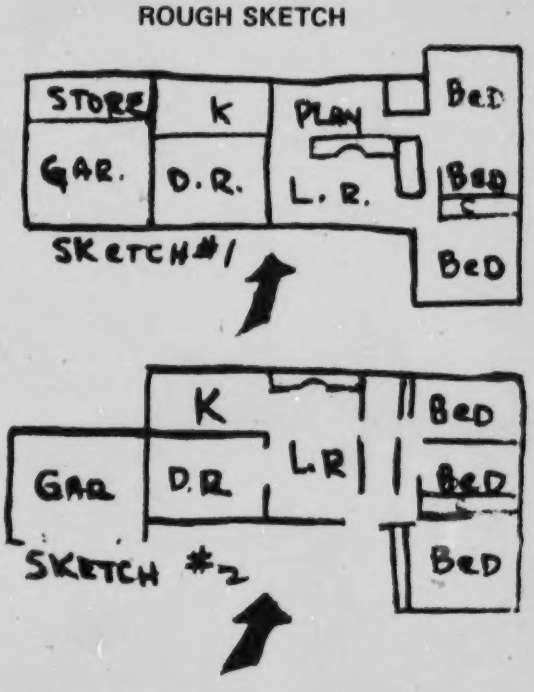
At the end of this lesson the student will understand how the architect serves the owner and builder.

Related Information:

To understand the role of an architect, assume that you are building a house, but your knowledge of construction is limited. Then your best bet would be to hire an architect for a set fee. The fee usually depends on the size of the job and the extent to which you use his services.

Thus with very little or no construction background, you could hire an architect to handle the construction from start to finish. The architect would get from your description a mental picture of your dream house. The architect would first draw preliminary sketches based on your ideas. To accomplish this, the architect would have to consider the following:

1. Basic needs of occupants
2. Appearance and style, based on preference and location plus lot characteristics.
3. Climate conditions
4. Materials available
5. Costs (available funds)
6. Building code



The preliminary sketches are usually free-hand drawings made somewhat in proportion, but not to exact scale. Sketches can be studied and considered and modified to meet your expectations.

The next step is to draw up final plans, estimate the costs, prepare specifications, and submit plans for bids. The architect can also act as supervisor during the cost of construction. The duties would be to make inspections during all phases of construction and protect your interests. The architect would consult with you and the builder from time to time on economies, substitutions, changes, and the quality of labor and material.

Hence, in a nutshell ... the architect acts as artist, designer, inspector, advisor, estimator, and judge in disputes. The fee can vary from 5% to 15% of the total cost. The extra cost is well worth it, if you are not qualified to do it yourself. The architect can also be hired to just draw up plans with no responsibilities for supervision.

Specifications Lesson 5

Objectives:

1. At the end of this lesson the student will understand what specifications are and how important they are.
2. The student will also understand how specifications cover each trade in detail.

Related Information:

Specifications in construction are a lot like instructions for a cake recipe . . . well, almost. Because, if you don't use the proper ingredients and follow the recipe instructions, you're not going to have a good cake.

Construction specifications work pretty much the same way. Ignore the specifications and you're sure to build a poor house. Specifications are written descriptions that explain the drawings. They *specify* the work to be performed, the degree of workmanship expected, and the extent of the work. In addition, they set forth the quality and the quantity of the materials.

Specifications are necessary because it would be impossible to put all the complex details of construction on a blueprint. If all the important data of construction were to be put on the blueprint, it would be so confusing it would defeat the purpose of the drawing.

The specifications are an important part of the contract. In many cases they have priority over the drawings in authority and importance. The drawings can have additions, corrections, or deletions made. However, once the contract is signed, the specifications cannot be changed without proper consent. They can only be changed by mutual consent of builder and owner by an addition called an addendum.

The architect prepares specifications that completely cover the proposed construction and divides them into general clauses and special clauses. The general clauses apply to almost every portion of construction to some degree and affect all grades. (See following pages) The special clauses refer to the quality of the materials, construction details and special details not covered by the general clauses. For example, here are a few special clauses:

1. Excavation

   (a) Excavation is based on normal conditions with standard excavating equipment. Hence any rock formation encountered that requires special equipment or blasting would be at the owner's cost.

   (B) Removal of excess fill, stumps, or trees will be at the owner's cost and a separate agreement must be made.

2. Carpentry

   (A) Owner will furnish special exposed oak beams for family room at his cost. Installation costs are included in contract cost.

SPECIFICATIONS FOR CONSTRUCTION OF HOME

BUILDER Joseph P Lucas

APPLICANT Same

____ Proposed Construction X Under Construction

1. FOUNDATION
   Wall footing size 16" X 8" ; Col. or pier footing size 24" X 24" X 12" thick.
   Foundation wall material: Below grade Cinder Block Thickness 8"
   Above grade " " Thickness 8"
   Top course " " Thickness 8" Solids
   Columns: Material and size 4" Steel conc. filled Number 7
   Girders: Material and size 6 x 10 Built up (wood)
   Foundation treatment Cement plaster - tarred below grade
2. FIREPLACES: Quantity 1 Description Used Brick - Flagstone hearth
3. EXTERIOR WALLS:
   Frame: Material Douglas Fir Const. No #1 Stud size 2 x 4
   Stud spacing 16" o. c. Sheathing: Kind ½ plyscord Thickness ½"
   Siding: Red Cedar Shakes
   15 lb. felt paper under siding: X Yes ____ No
   Exterior painting: No. coats 2 Material Dutch Boy Lead & Oil
   Gable wall construction: X Same as main walls ____ Other.
4. FLOOR FRAMING:
   Joists: Material Douglas Fir Const #1 First floor size 2 x 10 Spacing 16" o. c.
   Second floor size — Spacing — o. c. Bridging ____
   Concrete on ground: Mix and thickness 12.4 4" Thick Steel Trowel finish
5. SUB FLOORING: First floor size and material 5/8" plyscord
   Second floor size and material —
   Kitchen 5/8" plywood over Sub floor Bath ⅜" plyscord over 5/8" sub floor
6. FINISH FLOORING: First floor: rooms Oak floors except kitchen, fireside, & bath
   Species Red oak Grade No #1 com strip, ____ T & G. - 25/32
   Second floor rooms — Species ____ Grade ____
   All oak floors are end matched. yes Finish 2 coats floor lacquer
7. CEILING FRAMING:
   Joists: Size 2 x 6 Spacing 16" o. c. Material Douglas Fir Const No. #1
   Bridging: 5/4 x 3 Spruce
8. ROOF FRAMING: Size 2 x 6 Spacing 16" o. c. Material Douglas Fir Const #1
   Roof slope 5 "12" Knee braced Yes Collar braced Yes
9. ROOFING: Sheathing size and material ½" plyscord - Staggered Joint
   Shingles Material and grade 215 4 Asphalt Strip JM or Equal
   Underlay material and grade 15# felt
10. GUTTERS and DOWNSPOUTS: Material Clear Fir Treated Gutters 4x6" Leaders 2" x 3" Alum - Alcoa
11. INTERIOR WALLS: Size and material ½ Sheetrock U.S.G.
    X Taped X Cemented X Sanded
12. INTERIOR DOORS AND TRIM: Doors: Type Flush Material Birch
    Thickness 1 3/8" Finish Natural Paint ____ Stain X
    Trim: Type Pine - Natural Finish Varnish
13. WINDOWS: Type Double Hung Material White Pine Thickness of frame 1 3/8"
    Thickness of sash 1 3/8" Make Susser - Bylevel Line Corp
    Weatherstripping Aluminum full Jamb weatherstrip
    Cellar windows 4 - Prefit Weather Strip Deluxe
14. EXTERIOR DOORS: Main entrance door: Material White Pine thickness 1 ¾"
    Other entrance doors: Material Fir thickness 1 3/8"

15. EXTERIOR DETAIL: Exterior millwork: Painted X Stained ____ no. coats 2

16. CABINETS AND INTERIOR DETAIL: Cabinets, material Red Birch

Lineal feet wall cabinets 14' base cabinets 14'

Counter top: Formica 4/5" Back Splash

17. STAIRS: Basement: Material Fir 2x10 Risers 2x10 Treads

Main: Material — Risers — Treads

Rec. room: Material — Risers — Treads

18. SPECIAL FLOORS AND WAINSCOTS

Floors:	Location	Material description	Underfloor
	Kitchen	Vinyl Asbestos	
	Bath	Ceramic Tile (Main Bath)	
	Fireside Room	Vinyl Asbestos	

Walls:	Location	Material description	Height
	Bath	Ceramic Tile (Mosaic)	4' all walls, 5' over tub

19. PLUMBING:

	No.	Location	Make	Special Equipment, etc.
Sink	1	Kitchen	Amer Std	21 x 32 Double Bowl
Lavatory	2	Baths	" "	Bath - Cast Iron in Color
Water closet	2	Baths	" "	
Bath tub	1	Baths	" "	
Stall shower	0	—		
Tub shower	1	Main Bath	" "	
Laundry trays	1	Cellar	" "	

Water supply: X Community system ____ Individual system for this home.

Sewage system: X Community system ____ Individual system for this home.

Water piping: Material Copper tubing

Water heater: Size, how fired, make 30 gal. gas fired - 10 year warranty

20. HEATING: Hot Water ____ Baseboard ____ Cast Iron Baseboard ____

Loop System ____ With Main ____

Make ____

Warm Air X Forced X Perimeter ducting ____

Make G.E How fired Gas Storage capacity ____

Air Conditioning: Yes! - G.E or Equal

21. ELECTRIC:

Service: Overhead No. of boxes 50 Fixture allowance $100

Built in equipment: Built in Tappan Oven & Range

Special details: Exhaust fan for kitchen & ½ Bath

22. INSULATION: Roof: Material ____ Thickness ____

Ceiling: Material Rock wool Thickness 4"

Exterior Walls: Material Rock wool Thickness 2"

Other: ____

23. LOT, EXCAVATION, BACKFILLING, ROUGH GRADE, FINISH GRADE, SEEDING, DRIVEWAY, ETC.

Description: Crushed Stone Crushed Road Stone Driveway

24. PERMITS, INSURANCES, SPECIAL PLANS, ETC. By owner builder

MISCELLANEOUS. Attached 2 car garage, fireproofed and wired. Two foot overhang front & rear of house. Bilco door.

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The specifications are written for each trade and in the order that the construction will be performed. Thus, they would start with excavation and continue with masonry, carpentry, roofing, plumbing, heating, air conditioning, electrical, painting and decorating, and other trades the owner might wish to include (driveways, landscaping, etc.)

The specifications help to simplify the job of the contractors in estimating costs, ordering materials, etc. They usually indicate to the builder what alternatives or substitutions he is allowed in certain areas. Thus, the cost of the labor and materials can be more accurately established.

Finally, specifications, once accepted, are legal documents that protect the interests of the owner, builder, and architect.

Summary:

1. Specifications explain the drawings with regard to extent of work, workmanship, quality of materials.

2. They prevent misunderstandings and disputes.

3. Estimating is simplified and has greater accuracy.

4. General clauses cover all areas that might overlap or be overlooked.

5. They protect the interests of all parties concerned

6. They clearly spell out what substitutions, if any, can be made.

UNIT II – PLANS

The Written Contract **Lesson 6**

Objective:

At the end of this lesson the student will understand the important role of the written contract.

Related Information:

Did you ever hear the expression "talk is cheap"? Well, it's true, and that's why the written contract is so important.

Every science teacher knows that when John Wayne and other good guys were settling the West, a man's word was his bond. Guys used to trade horses and steers on a mere handshake – until the Big Depression. Then everybody got sneaky and started to lie and cheat, and that's how written contracts took hold.

Written contracts bind all parties to deliver their services and materials in the quality and the quantity and method agreed upon.

Written contracts in building are advisable as follows:

1. With the purchase of land (with the seller of the land)
2. With the architect
3. With the builder
4. With the material suppliers
5. With other contractors (not covered by builder's contract)
6. Some agreement with surveyor and attorney

Competitive bids can be accepted or rejected. The decision to choose one over another is made after consideration of the integrity, ability, performance record, and financial responsibility of bidders. The lowest bid may not always be the best, and the best appearance does not necessarily indicate the best contractor.

Contracts should be prepared by an attorney familiar with or specializing in building and real estate. Stock legal forms are available at stationery supply stores, but a "do-it-yourself contract" can be a dangerous gamble.

Why a contract is so important

The language of the contract should be clear, nothing of importance should be omitted, and clauses should be included regarding delays due to labor, weather, strikes, etc.

Loan applications depend on contracts, so that the true value of the construction is known. Lending institutions require a copy of the plans and specifications plus estimated value before they will issue a firm letter of commitment.

Note: A letter of commitment is a written legal commitment that the lender (bank) will lend a specified amount of money. It stipulates the terms of the loan--mainly as to how much money is to be released at certain stages of construction.

Warning:

1. Avoid verbal agreements.
2. Read a contract carefully before signing.
3. Have a lawyer to protect your interests.

UNIT III – EXCAVATION

Review of Matter **Lesson 1**

Objective:

In this lesson the student will lay his own foundation for understanding the nature of soil and its relation to excavation. He will know about several of the properties of matter.

Related Information:

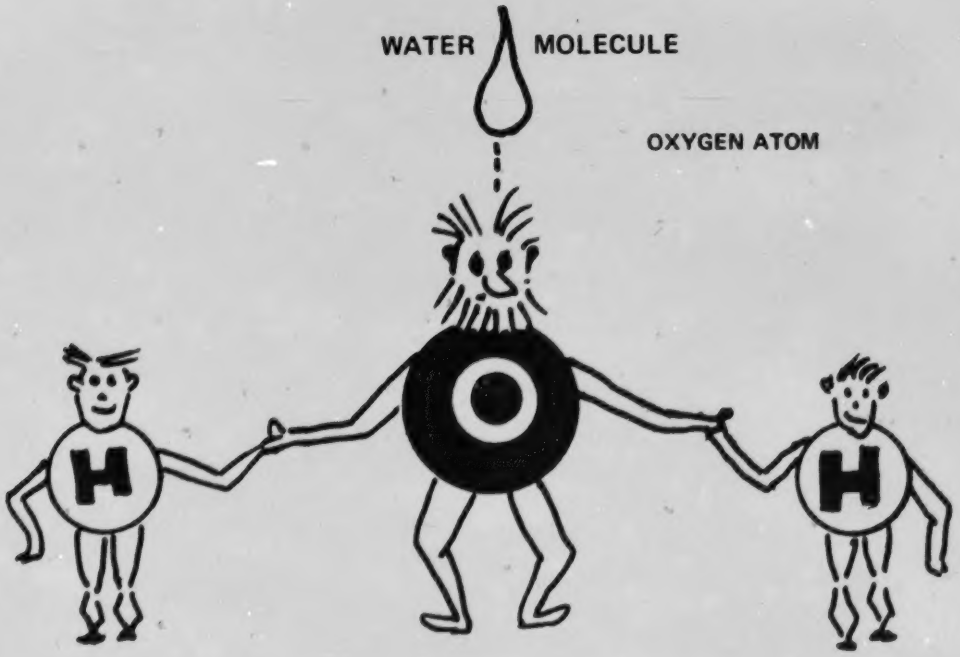
The type of "matter" that a house is set on determines the type of foundation. For example, the soil in many parts of Florida has water just below the surface, making a cellar impossible or at least impractical.

The purpose of this lesson is to make a swift review of matter to clear up any confusion. Yes, there is confusion. Too many students have been running around the school asking "What's-a-matter?" School principals take a mighty dim view of students running around with fuzzy concepts, and naturally blame science teachers.

. . . . . And so, by popular request (mostly principal's), we will review "What's-a-matter."

A. WHAT'S-A-MATTER. Matter is anything that occupies space and has weight. It is found in three forms – solid, liquid, and gas. (Perfect example: a lazy student. "It" occupies space and has weight.)

B. STRUCTURE OF MATTER All matter is composed of very small particles, called atoms and molecules. Each *molecule* represents the smallest piece that a material can be reduced to and still retain its properties. For example, water (chemically H_2O), when reduced in size beyond its smallest speck (a molecule) will divide into hydrogen and oxygen *atoms* – it will no longer be water.



C. PHYSICAL PROPERTIES OF MATTER. Matter has certain characteristics:

1. Mass and weight
2. Density
3. Volume
4. Adhesion
5. Cohesion
6. Porosity
7. Impenetrability
8. Inertia

COHESION:
Like Molecules
Attract each other
With strong force

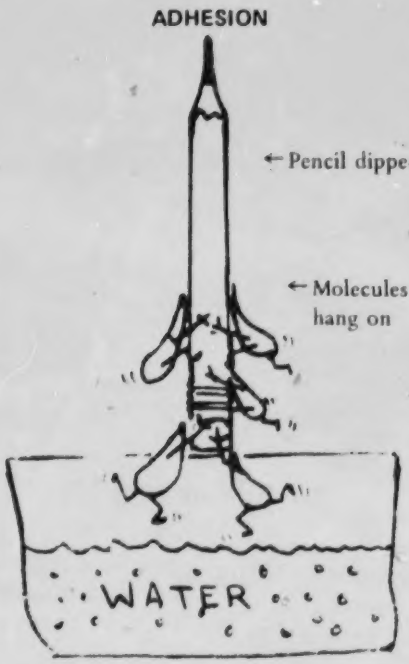
Cohesive force of molecules is what makes drop of water round

In this lesson we will review four of these, leaving the other four to show up in other lessons.

Cohesion: The tendency of molecules of the same material to attract one another (to stick to *like* molecules).

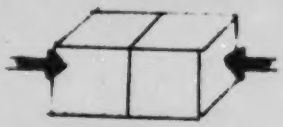
Cohesion: Like molecules stick together

Adhesion: The tendency of *unlike* molecules to attract one another.



ADHESION

Unlike molecules stick together



Cohesion:
Like molecules

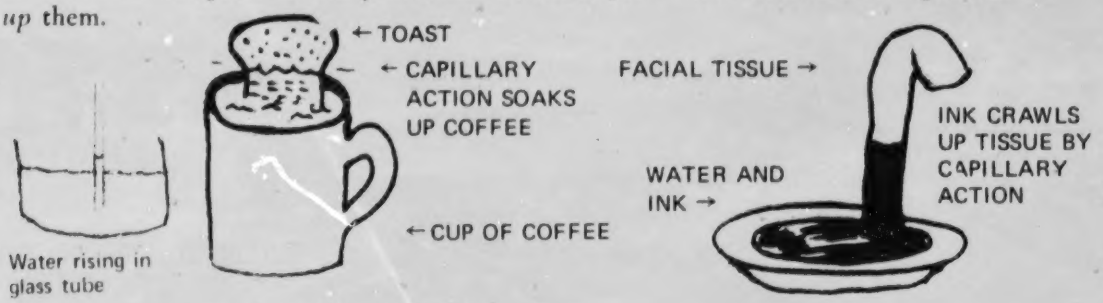
Adhesion:
Unlike molecules

Density: Matter is often classified as light or heavy. This comparison is based on the weight of a material in proportion to its size. For example, a cubic inch of lead is much heavier than a cubic inch of meatball. So we say that lead has greater *density* than meatballs (or is *denser.*)

Meatball Lead ball

Porosity: Matter is said to be *porous* when it has large air spaces in it. For example, a sponge and a paper towel are very absorbent – water can take the place of the air pockets – so they are described as porous.

Capillary action: Liquids seem to defy gravity in many situations in the building trades, and this is due to a tendency called capillary action. It seems that a liquid in a narrow tube will pull itself up by a combination of the forces of adhesion and cohesion – first clinging to the walls of the tube and then evening out; then clinging, then evening out; and so on. The spaces in many materials in effect *form little tubes*, and so liquids crawl *up* them.


Water rising in glass tube
← TOAST
← CAPILLARY ACTION SOAKS UP COFFEE
← CUP OF COFFEE
FACIAL TISSUE →
WATER AND INK →
INK CRAWLS UP TISSUE BY CAPILLARY ACTION

CAPILLARY ACTION

Capillarity in house construction can be useful or troublesome, depending on what it is doing. If it is pulling moisture through the foundation or walls – that's mischief, and it's bad. If it's helping a preservative sink into wood and preserve it – that's good.

D. THE THREE STATES OF MATTER. Note: The forces between molecules determines the state of matter.

1. A solid – is matter in which the molecules vibrate, but still are tightly packed together by the attractive force between them. A solid keeps its shape pretty well.
2. A liquid – is matter whose molecules have enough motion of their own to overcome some of the attraction between them. A liquid takes the shape of its container.

3. A gas is matter whose molecules have no attraction for each other but are in constant motion. Thus, the molecules of gas can wander off (evaporate) because the cohesive force is weak. If in a container, a gas takes the shape and volume of the container.

COMING NEXT . . . . . The next lesson explains how the science of matter relates to house construction. Don't miss it.

UNIT III – EXCAVATION

Purpose of Excavation **Lesson 2**

Objective:

At the end of this lesson the student will understand why excavating is necessary.

Related Information:

HISTORICAL FICTION, OR "HOW THE WEST WAS SETTLED"

Many years ago, when the original settlers came to America and landed at Seaside Heights, a terrible thing happened. There was a terrific housing shortage due to a rich clam-strike that brought prospectors from everywhere. There wasn't a single cave to be rented, leased, or bought, and so the settlers were forced to build.

Science books were very hard to come by, and so the settlers – with no science books to back them – started to build houses without excavating for foundations. They just placed the houses on four rocks.

Well, each year when the northeast storms hit, the buildings would move a whiz. The winds would sweep over the Garden State Parkway something fierce, which made the houses move west faster. The houses kept moving until they crossed the Rockies. And that's how the West was settled.

Naturally this was a terrible shock to these "foreign folk," and so they kept prodding their kids to study science. That is why folks today are very science-conscious now and keep asking one another, "Do you dig it?"

The primary purpose of excavation is to reach a sound base for the foundation, so as to support the load of the house. In cold climates a sound base would be deep enough below ground level to be protected from frost action. The local building codes establish a safe and accepted level to guide builders.

Excavation can serve other purposes as well:

1. It can provide storage space.
2. It can provide secondary living space.
3. It can protect the foundation from damage by man or nature.
4. It can avoid settling that results in cracks in the structure.

A good builder will check the subsoil conditions before excavating. Checking can be accomplished by:

1. Test borings by builder (soil samples)
2. Commercial drilling companies
3. The city engineers
4. Other government agencies
5. Or information may be available from neighbors.

Factors Affecting Excavation Lesson 3

Objective:

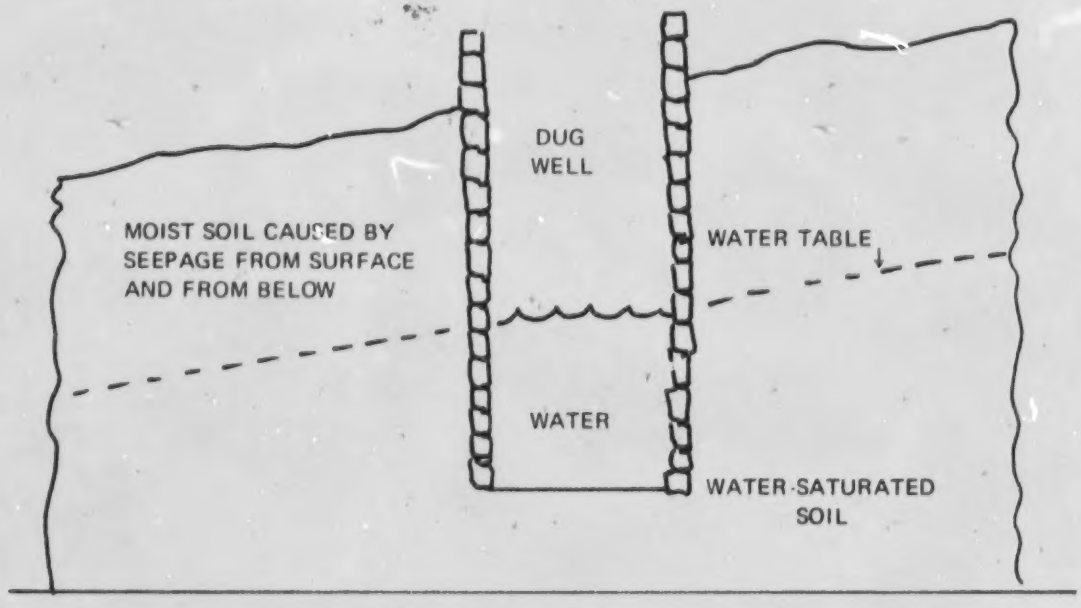
At the end of this lesson you will understand what the different problems are that affect the depth of an excavation.

Related Information:

From the previous lessons we know that soil is a solid state of matter. Due to the force of cohesion which certain soils have in great measure, excavating in these soils presents extra problems to the builder. Let's see what the builder may encounter when he sets out to dig a foundation:

Clay: Clay has a very fine, powder-like texture, like flour or bath powder. This type of soil is quite cohesive, which means it sticks together well. In fact some clay soils stick together so strongly that they are as hard to excavate as solid rock.

Rock: Rocks can vary in size from pebbles to boulders to solid-rock formations. Huge boulders or solid rock require special equipment and sometimes blasting. Removal of rock also creates soft voids that can require expensive reinforcement rods to offset instability.



The Water Table

Hard Shale: Shale is layered rock that is extremely difficult to excavate with the average power shovel or dozer. It can frequently require blasting and special machinery. As a result it is usually costlier to build on shale than on soil.

Sand: Sand is relatively easy to dig but provides a loose base. Machine tracks in the final cutting loosen the base, which should be compacted before pouring footings.

The water table also affects the depth of the excavation. You are familiar with the moisture in the surface level of the soil. It comes from the rain and snow that fall and also from the water table below, by capillary action.

The water table consists of underground rivers and lakes. This water generally follows the contour (shape) of the land in a current – sort of like a trout stream. This natural ground-water line may be very close to the surface or it may be quite deep. Excavation calls for good judgment Going below this water table can create problems in excavation, installation of foundation, waterproofing, and drainage. Since conditions can vary so greatly, only an experienced excavator or engineer should make excavating decisions.

Climate affects construction in many ways. For example, the depth of frost in the ground depends on the climate. And every good would-be builder knows that sound footings should be below the frost line. Other climatic factors affecting excavation include the likelihood of hurricanes or tornadoes, and the average amount of rainfall. Hence a knowledge of prevailing climate is necessary for accurate decision-making in excavation.

Air and water also affect soils. Most soils are affected by water and will swell when water is added and shrink when it is removed or dried out. Clay, for example, is composed of tiny, fine particles like dust that have a great cohesive pull. Water can affect clay soils in many ways: the soil may swell, shrink, or turn into a semi-plastic, jelly-like mass, or it might lose strength. Water can also, by its freezing action, cause soil to expand or swell; then, as it melts, the shrinkage may cause a drop in grade level.

Because of the effect of air on soils, it is advisable to postpone final trenching of footings until the time to pour the concrete. Some soils will become soft if exposed to air, and certain clays will lose their strength by the drying action of air.

The effects of air and water on soils should be borne in mind by a builder. If he has any doubts about the particular soil he is dealing with, he should consult an engineer. When necessary, soils can be scientifically analyzed as to stability and density in a laboratory.

One other factor influencing the depth of excavation is the design of the structure. The overall size and weight of the structure must be considered in deciding the depth and extent of the excavation. For example, residential construction loads are relatively light, and excavation need only reach a sound base below the frost line. A high-rise apartment or industrial building might require additional excavation and footings – and in extreme cases driving pilings to support the structure.

Now we can summarize the different factors that need to be considered when planning an excavation:

1. General type of soil and any particular characteristics
2. Depth of the water table
3. Design of the structure
4. Climatic conditions
5. Cost (blasting might be too costly).
6. Utilities (depth of street sewer line)

THIS LESSON ENDS WITH A QUESTION . . . . . Is it important to remove guesswork as to the nature of soil before building?

THIS LESSON ENDS WITH THE ANSWER . . . . . Yup!

Without this lesson, folks will have to go through life performing the "stomp test" for soil. The stomp test requires that you "stomp" the proposed excavation site in your bare feet. You jump as high as you can in the air, waving your arms like a windmill, and shout "What's the matter?"

HOW TO INTERPRET STOMP-TEST RESULTS . . . .

Solid ground – very little bounce, making your feet smart.

Clay – faint prints of heel and toes and fallen arches.

Swamp – you disappear into the bog and have to be rescued; or your friends tell your widow.

Laying Out the House **Lesson 4**

Objective:

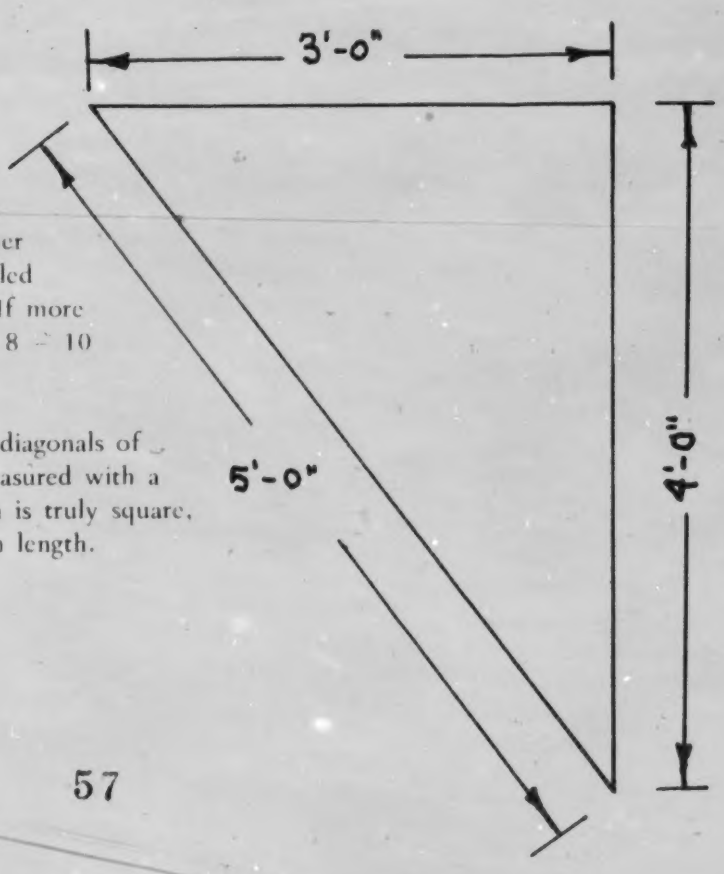
At the end of this lesson the student will understand how a house is placed on a lot.

Related Information:

The first step is performed by a registered surveyor, who sets up guidelines for the excavator, mason contractor, and builder after the site has been cleared.

The surveyor establishes the corner markers of the lot by means of an instrument called a transit, a tape, and calculations. The surveyor will further lay out oak stakes with nails, indicating the outside lines of the foundation walls. On request, the surveyor will offset the stakes 5' on each corner, thus allowing the excavator to work his machine without disturbing the stakes.

The science of mathematics should be used to assure square corners on the foundation. To do this we use the fact that, in a triangle where one angle is exactly a right angle, we can lay off 3 units along one edge, and 4 units along the other edge, and the line connecting these two points will be exactly 5 units long. If it is not, we must adjust the corner angle until it is. This is called the 3 – 4 – 5 method. If more convenient, measure off 6 – 8 – 10 units: it works just as well.



As a further check, the two diagonals of the foundation should be measured with a steel tape. If the foundation is truly square, the diagonals will be equal in length.

UNIT IV – MASONRY

Purposes of the Foundation **Lesson 1**

Objectives:

1. At the end of this lesson the student will know why a foundation is necessary.

2. The student will also understand that a poor foundation will affect future repairs and value.

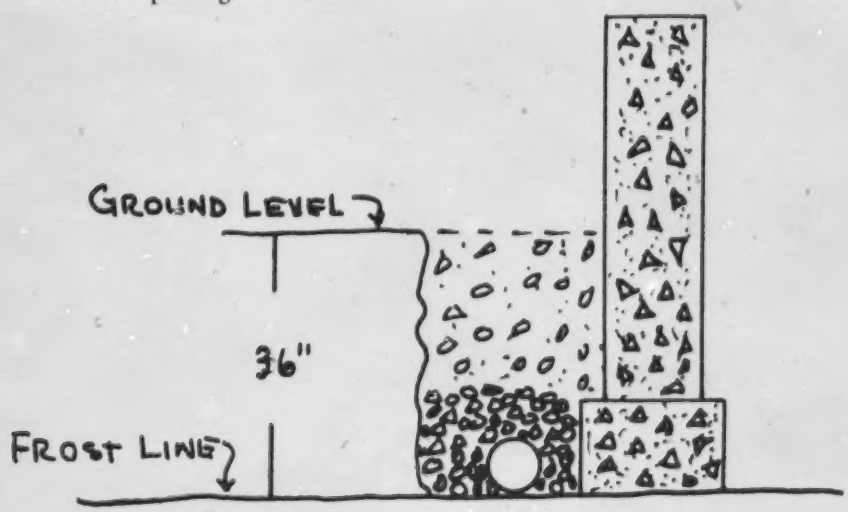
Related Information:

Did you ever hear the expression, "The buck stops here"? Well, it was an expression first used by President Harry Truman. It means that passing the blame on to someone else eventually comes to an end at the President's desk. This same thought can be applied to foundations.

The successful construction of any house depends on the soundness of its foundation . . . You can't "pass the buck."

The following are some functions of a foundation. You will see why proper design, good materials, and professional workmanship are so necessary.

1. *Foundations provide support.* The foundation walls carry the weight of the entire structure above it – walls, floors, ceilings, and roof. All parts of a house depend to some degree on other parts, and eventually the foundation supports them all. The quality starts here . . . there is no "passing the buck."



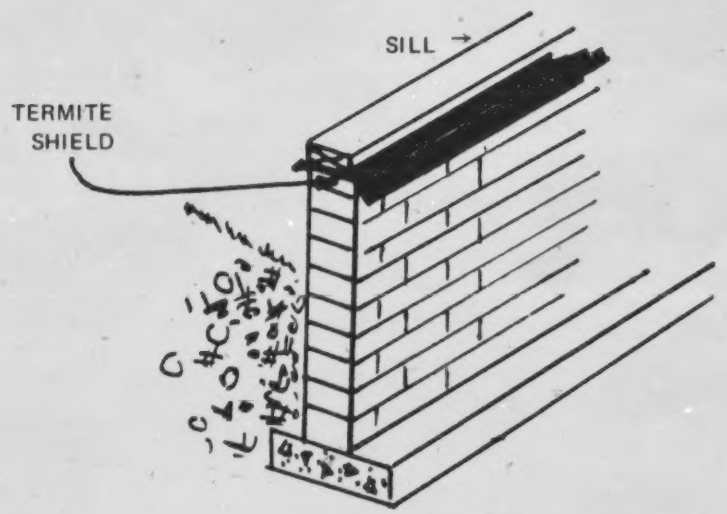
Footings must be below frost action

2. *Foundations protect against action of frost.* To understand why this is so, let us see what happens when water freezes. Materials on freezing change from a liquid state to a solid state. Most materials contract or shrink during freezing, but water *expands* when frozen into ice. This expansion is due to the rearrangement of the molecules, that now require more space as ice than they did as water.

Thus we can easily understand that soil containing moisture will expand as it freezes. As soil freezes, it needs room to expand. Since there is less pressure from above, this causes the ground to push upward, which is called *heaving.* Then as it thaws, it settles again. This up-and-down motion would cause cracks and other serious structural defects to a building resting on the soil. The only way to protect the building is by using a foundation to extend below the level of frost action.

3. *Foundations can provide storage, utility, and living space.* Foundations form an underground enclosure for basements and a protection against soil and water pressure. A dry basement can supply storage areas and areas for recreation, laundry, and heating units.

4. *Foundations can provide protection from insects.* In many parts of the United States, termites, ants, and other wood-boring insects can eat away parts of the structure. The foundation acts as a first line of defense by keeping wood away from direct contact with the soil.



Mini-Facts

Termite shield – a protective shield made of a non-corrosive metal that fits over the foundation like a metal hat. It is also placed around plumbing pipes to keep out those little rascals –– termites.

Termites are whitish wood-devouring insects that resemble ants in appearance and in habits – by living in colonies in the soil – but they really are a different breed of critter. They cannot stand exposure to light and air. But certain termites are so determined to get a good meal that they make mud tunnels on the outside of masonry to provide a pathway from ground to wood.

Termites as pets – Many, many years ago before riots and demonstrations were popular methods used by rebellious students, the kids would use the "termite trick." Mean, vicious students would raise and train termites to snap up school desks and seats. The destruction was so terrible that classes had to be called off, and soon every school had "termite days" –– similar to our present "snow days." Well, dedicated science teachers cured that by developing a termite cocktail. An imitation-wood sponge would be soaked with cocktail juice, of which the termites would partake. The termites would get silly (stoned) and couldn't tell wood from steel. They would ruin their molars on the metal and die. Science triumphs again!

UNIT IV – MASONRY

Kinds of Foundations **Lesson 2**

Objective:

At the end of this lesson the student will know the most popular foundation types and the advantages of each.

Related Information:

Once upon a time when George Washington was just a kid, a fierce classroom debate decided the importance of lessons on foundations. A kid named Brute asked the teacher, "What do persons called students need with lessons on foundations?" Well, normally the teacher would ignore such class participation, but this kid happened to be very tall and very large and so he got an answer. This is that historic reply . . .

"Today's students are tomorrow's homeowners with big mortgage payments. This is when a good foundation is important. A dry, waterproof basement is especially important to male persons when they lose an argument. Some marriage counselors claim that some husbands spend as much as fifty percent of their married life in the cellar. These experts highly recommend dry cellars to protect male persons on those days that they lose."

Now, the real facts . . .

The type of foundation depends on the soil conditions, building codes, climate, and the load to be carried. It also depends on whether a basement is desired. Where there is a full basement, the foundation forms the basement walls. If a house is to be built over a crawl space, the foundation may be a masonry wall, or (to save money) the house may be simply set on piers. Again, in areas where the soil does not permit a foundation as usual, then pilings may be driven into the soil to support the building.

There are two basic kinds of foundations that can be used. The choice depends a great deal on the availability of labor and materials, plus the consideration of costs:

1. **Poured Concrete Foundations.** – This type is normally considered the best because it tends to crack less and leak less. The entire foundation is poured at one time; thus it becomes a single, solid unit. It also costs less for labor, since the forms can be placed and the concrete poured with unskilled labor. The poured foundation can withstand greater soil and water pressure and is usually watertight. The density of the material is greater, and it resists abrasion and deterioration better than block foundations. The disadvantage is that it is not too flexible for changes or additions.

2. **Concrete Block Foundations.** – This type of foundation is widely used and highly satisfactory if carefully built. Since the blocks are large units, the foundation can be speedily erected. This type is especially useful where concrete is unavailable, too expensive, or impractical because of lack of access.

A "True Story" About the Origin of Footings **Lesson 3**

Objective:

At the end of this lesson the student will know the truth and the whole truth about the origin of footings – the facts that most history books are afraid to tell.

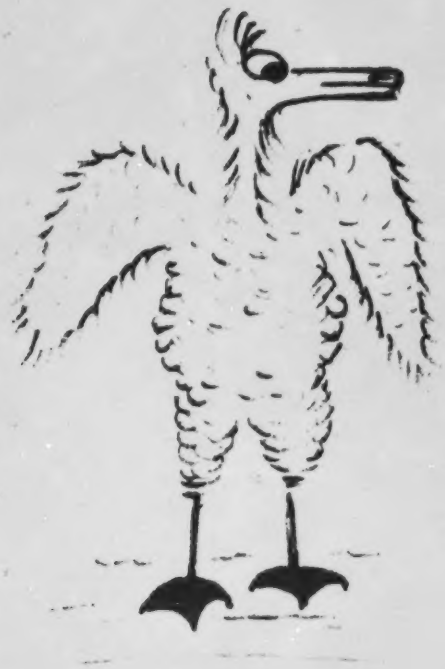
Related Information:

Many, many years ago, everything with feathers that could fly was called foul. Chickens were often classified as "real foul." In a sense there was some justification to this label, because their feet were always covered with sticky mud from the barnyard. But this mean, vicious label caused some of the chickens to rebel. These were the "concerned" birds, concerned about ecology (pollution, environment and community health).

This concerned group was worried about barnyard conditions, especially the wet spongy soil condition and its effect on safe footing. These birds formed a study group, that started from scratch and developed the first scientific theory on footings.

This in-depth study revealed that many serious foot ailments, such as athlete's foot, arthritis, water on the knee, and gout were all caused by poor footing. This group found that chickens' feet were poorly designed to carry the chicken-and-egg load. This poor design caused chickens to sink up to their kneecaps in barnyard mud. The concerned group now had a mission –– to improve shaky balance and squiggly footings. But how?

The concerned group recommended that flaps be sewed between the toes. The object was to distribute the load so that birds could walk on mud and mire with ease and stability. The first design was a smashing success. No longer did muck squirt or ooze between their toes, and stable footing was now possible.



The concerned group went wild with joy and decided to split with the old uptight birds (who preferred things as they always had been). The first thing they did was to change to mod feathers and greasy kid stuff to waterproof their feathers. They next decided to go all out and change their name to "ducks." Thus they created a new scene.

To this day web-footed ducks with greasy feathers run circles around the plain chickens, because they can navigate on any type of soil.

During all this commotion, architects and builders were hiding in the weeds, making careful observations and taking notes. This sneaky group decided to copy the ducks, and the first thing they designed were devices to improve their own footing.

One of man's first footing problems was to walk on snow, and so he designed snowshoes. Snowshoes worked just like ducks' feet – they spread the load and distributed the weight. The next problem was to travel in muck and mud, and so man started to place flat boards and rocks to keep from sinking.

Then man extended his ideas on distributing the load to paved roads, and now wagons and trucks were able to meet their delivery schedules.

At last man applied the idea of spreading the load to his houses, schools, saloons, and other places of rest and recreation.

He devised the idea of a wide platform under the base of foundation walls so the buildings would not sink down and perhaps disappear from the face of the earth in a bad rainstorm.

Just think – if it wasn't for footings you would still be living in caves, and there would be no schools. Isn't that a horrible thought!

UNIT IV – MASONRY

Importance of Footings **Lesson 4**

Objectives:

At the end of this lesson the student will:

1. Understand why the guess-and-mess method of making footings will not do.

2. Apply tried-and-true methods based on science.

3. Follow a set of proven rules to avoid future problems.

Related Information:

A footing gives a house the same stability as a duck's foot in mud or a pair of snowshoes on a hunter's feet. They all *distribute the wieght of the object,* providing stability and preventing sinking. Therefore, if you want to avoid basement leaks, building cracks, or sticking doors or windows – install the footing properly. The footing of a house is the concrete pad or snowshoe on which the foundation and the house rest. So let's go.

1. *Ye Olde Guesswork Method.* – Sloppy, shaky, unstable footings are easy; all you have to do is eliminate common sense. The trick to this method is to start off confused and maintain this way-out state all the way. First, select any spot on the lot and start digging like a madman. Be sure to ignore the depth of the excavation, the type of footing, and the size. Footing forms? Who needs them! Then order concrete, but don't specify the mix, and refuse to give the concrete company the delivery address. This keeps everybody guessing. If the truck does arrive through some error, let the driver add water until the mixture is like soup. It spreads more easily that way. By using this method, whoever lives in the house will "bless" your name for ever and ever.

   Exaggerated, you say? Sure, but guesswork and carelessness will produce disaster every time.

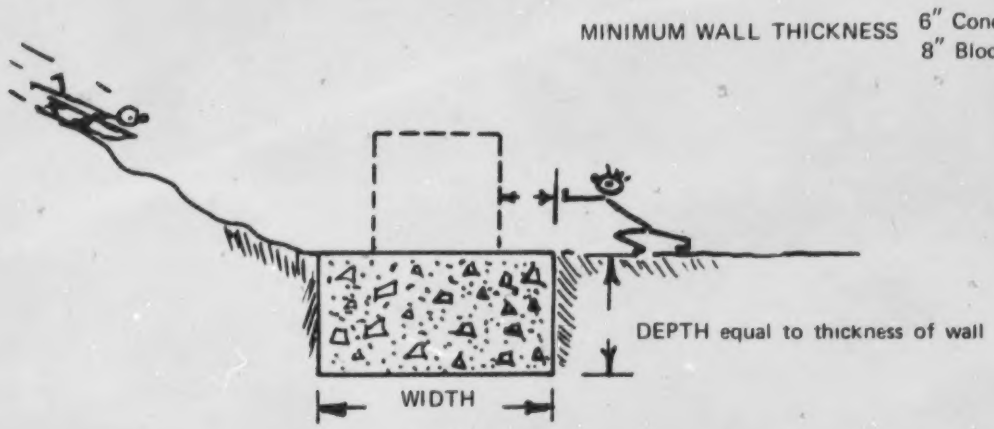
2. *Right Method – Based on Science*

   a. **Soil Conditions.** – Normal conditions would consist of a hard-pan type of soil or very firm, well-drained soil. Should you encounter a filled-land situation, the footings should go deeper and reach undisturbed solid ground. Any abnormal soil conditions, such as loose sand, clay, fill dirt, or water require special treatment. Then the footings should be made either wider or deeper or have special reinforcements added.

b. **Weather.** – Footings should extend far enough below the frost line to protect against heaving and settling. This is not only practical from the point of view of science but is required by most building codes. Most codes in New Jersey for example, require a minimum of 3 feet below grade.

c. **Compressive Strength.** – These are fancy words, for sure, but mighty important, so hang in for translation to student language. Adequate compressive strength means that the weight of the load (house) on the concrete footing will be supported without failing or crushing. For example, a certain footing placed on solid, bearing soil will withstand a load of 2,000 pounds per square inch without failing or crushing. Hence 2,000 pounds per square inch is its *compressive strength.*

d. **Tensile Strength.** – This means the ability of a footing to resist being torn or broken apart. Concrete by itself has very little tensile strength. Therefore, if the soil conditions are poor, you need something to improve it. Steel rods or reinforcement have an excellent tensile strength and so should be added. Now, the concrete "borrows" the tensile strength of steel, and the footing strength is regained.



Determining Size of Footings

e. **Size**

To determine *width* of footings – double the width of the wall.

To determine the *thickness* – measure the width of the foundation wall and use that measurement.

(Note: This is a simplified method, based on firm soil conditions.)

Example:

Proposed foundation wall is 8″ thick and 8′ high.
Width of footing = 2 x 8″ = 16″
Thickness of footing = 8″

3. *Do's and Don'ts*

a. Footings should be made of poured concrete.

b. Follow recommendations of building codes and concrete suppliers as to type of mixture and weight-bearing ability of concrete.

c. Concrete footings should be poured continuously. No load should be placed on the footings until the concrete is properly firmed up.

d. Avoid excessive water in the mixture. It may make it easier to spread, but it will weaken the footing. Footings should be poured fairly stiff.

e. When in doubt as to thickness of footing, use this rule: *Never make thickness of footing less than thickness of wall.*

f. Footing width should be designed to bear the load. Under normal conditions make it at least twice the width of the wall it is to support.

g. Never use fill dirt if the trench is too deep in spots. Use additional concrete – it may cost a little more now, but it is cheaper in the long run.

Form Construction for Footings **Lesson 5**

Objective:

At the end of this lesson the student will understand the use of forms in making footings.

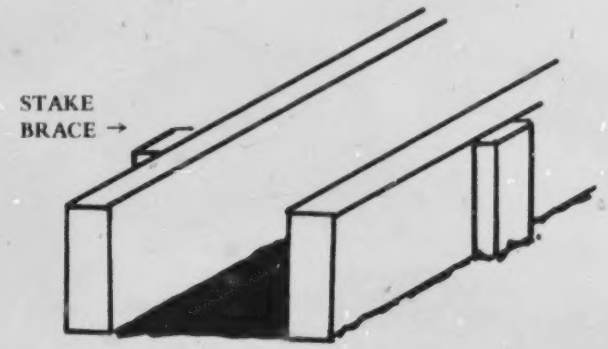
Related Information:

The main purpose of this lesson is to learn how to build proper forms for residential homes (or how to keep concrete out of your shoes). You may never have to build a form in your life, but at least you will know good from bad. Sneaky contractors will avoid you as they do taxes, and you will live a long, happy life.

Simple concrete forms for residential construction can be constructed from rough materials or less-expensive framing lumber. Form stock should be selected from clean, straight, and strong lumber, like 2 x 8's or 2 x 10's in long lengths.

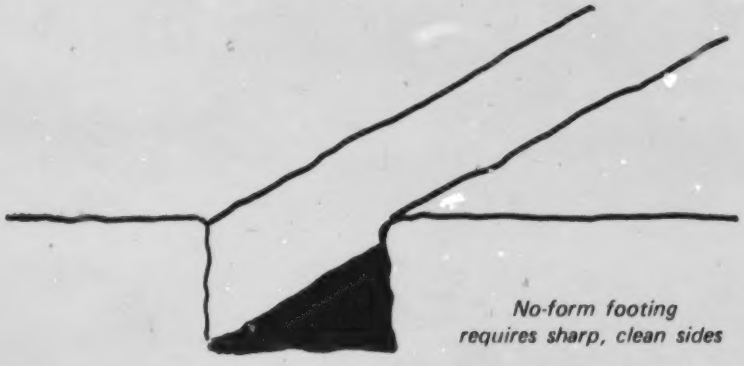
After the forms have been properly built to desired measurements, they should be leveled, braced, and the entire unit squared. The next step is to oil the forms to prevent the concrete from sticking to them, which makes removal difficult.

FORMS MUST BE STRAIGHT, FIRM, AND PROPERLY SIZED



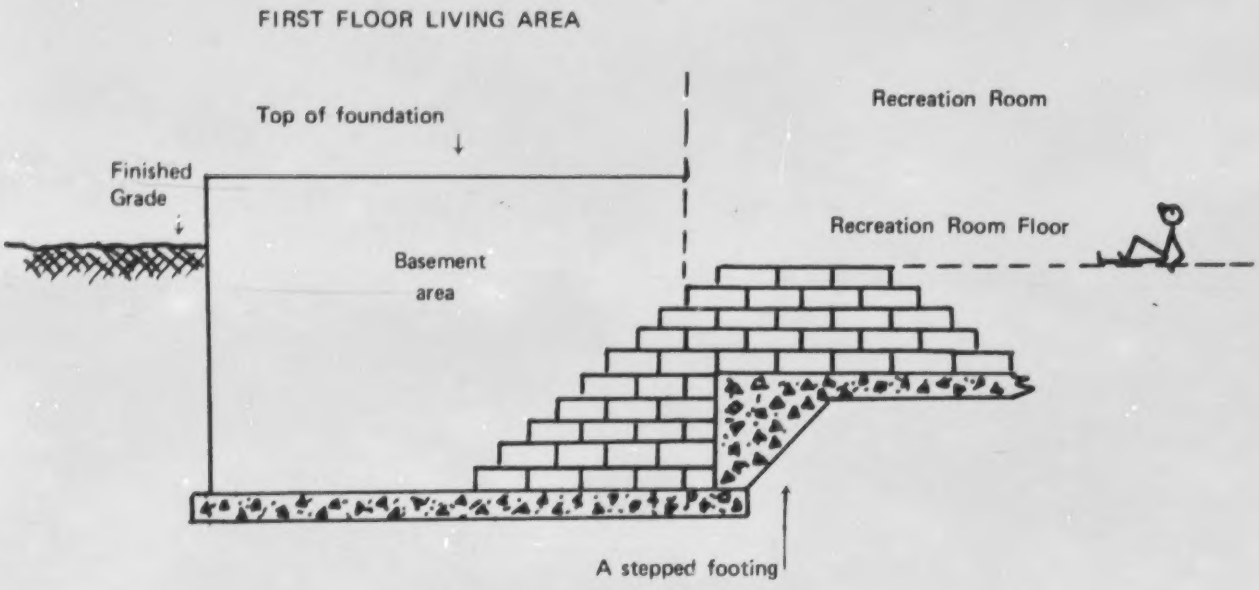
Concrete exerts great pressure, and forms must be strongly braced and tightly constructed to avoid bulging or leaking.

Leveling and squaring are an absolute must – unless you like crooked houses. If you're fond of crooked houses, then save all your old textbooks so that you can level the furniture and appliances.



No-form footing requires sharp, clean sides

Some footings can be installed by cutting and excavating a clean trench. However, the earth must be firm and solid, and good weather is necessary to avoid damage. This method can conserve time and labor, but the soil must be firm, solid, and not too porous.



In some cases a footing must be stepped or set at different levels. The slope of the land, obstructions, or the design of the house may require a stepped footing. The basic principles remain the same – the rest is common sense.

UNIT IV – MASONRY

Code Requirements **Lesson 6**

Objectives:

1. At the end of this lesson the student will understand that building codes are part of the law and *must* be followed.

2. The student will also understand that building codes regarding masonry provide quality and safety safeguards and *should* be followed.

Related Information:

When our country was a young teenager, there was no need for building codes. After all, there was just so much you could do with a log cabin or sod house plus an outhouse. However, as the person-population increased, persons not only stomped on one another's feet, but they built all sorts of buildings, some of which endangered life and limb. Sagging houses, leaky plumbing, and overflowing septic tanks caused tempers to flare, and so building codes were developed.

Most building codes cover every phase of construction, including such items as excavation, masonry, framing, electrical work, sanitation, etc. These building codes are based on the type of soil, climate, and structure. In general, all plans, specifications, and construction methods must meet or exceed the established code.

Most masonry codes include the following major points:

1. **Climate**: In cold climates the masonry base or footing must extend below the frost line. This protects from heaving and thawing, thus avoiding movement and cracks.

2. **Soil conditions**: Soil conditions vary from area to area, and footings must be designed accordingly. The footings must support the building weight effectively and evenly, and thus codes require they be set on solid ground. Other than solid ground requires special footing design, reinforcement, or construction methods.

3. **Temperature**: Temperature plays a vital role before, during, and after pouring concrete. Most building codes prohibit work at below freezing temperatures. Thus a good rule to follow is: Don't pour concrete when the temperature is below 33°F. and getting colder. Masonry that is completed should be covered with insulating materials to keep it from freezing; and most codes require this.

4. **Forms**: The sizes of footing and wall thickness, width, and design should comply with local codes. Forms must be accurate, neat, and well braced in most cases before permission to pour is given.

5. **Concrete**: Concrete must meet specifications of the local code, based on the load-bearing ability. The load-bearing ability, usually measured in pounds per square inch (P.S.I.), depends upon the concrete-mix ratio of sand,

THE CASE OF THE CONCRETE THAT LOST ITS STRENGTH
DELIVERED 11:00 A.M.—5 yds.
slump: 4"
strength: 2500 psi
11:02 A.M.
5 more gallons of water!
slump: 5" strength: 2300 psi
11:10 A.M.
10 more! What'cha trying to do—break our backs?
slump: 7½"
strength: 1800 psi
11:15 A.M.
A little more water ought to do it . . .
slump: 9"
strength: 1400 psi
3 DAYS LATER
Cracks! What the heck happened? Where's that concrete man?

cement, and gravel. The mixing must be done on the site, and the addition of extra water is not permitted by code. The delivery ticket specifies the mix ratio, water to be added, and pound test of mixture.

Note: In general, the building inspector enforces the code and must inspect and approve of all phases of construction. This includes inspection of the depth of the excavation, the footing forms, and periodic on-the-spot inspections of the work in progress.

UNIT IV – MASONRY

What Is Cement? **Lesson 7**

Objectives:

1. The student will learn a hazy, hysterical history of cement – the Rock Age Scene.

2. At the end of this lesson the student will understand what cement is, how it is used, and the advantages.

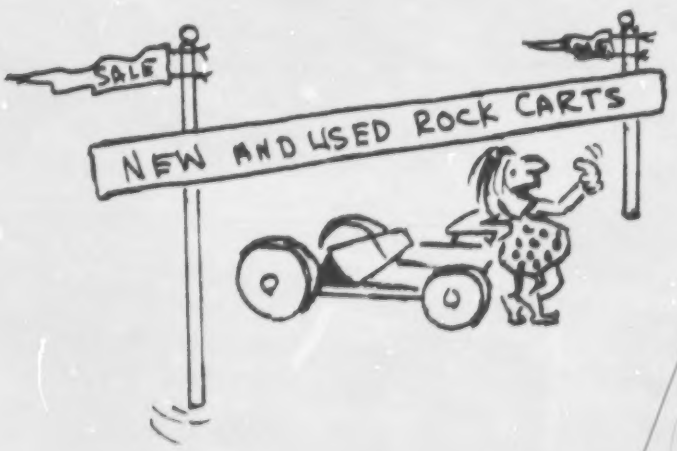
Related Information:

Masonry materials are used in construction because of the following advantages:
1. Strength – they have the ability to support heavy loads.
2. Toughness – they have the ability to withstand soil pressure, water pressure, etc.
3. Durability – they have the ability to withstand wear and tear for long, long years.
4. Economy – they are inexpensive, plentiful, and practical.

Beautiful advantages! But how do you *combine* masonry materials – make them stick together – to make a construction that has the strength, toughness, durability, and economy that masonry materials are capable of?

Well, this explanation belongs to the history department – not the science department. So, let's check the blurred pages of history – the coke stains make it the "real thing".

1. Rock Age Scene (Hazy History, Vol. I). – Folks called "rock snappers" in the Stone Age provided vocational education for rock diggers, rock rollers and rock and roll groups, but somehow they forgot "rock joiners" (as the masons of the day were called).



What made the scene worse was the condition of the rock market. The rock market was really in bad shape. It had taken a big tumble. All the used-rock lots weren't moving a thing – except small, compact "foreign pebbles" here and there.

Then along came some folks called Egyptians, and their kinfolks the Romans and the Greeks – a real rock set. Well, this group really got the rocks rolling, and to this day folks call them the "rolling stones".

They started to put the rocks together with lime and plaster of paris. That's right – by using this natural cement they threw up the Colosseum, some pyramids, a number of aqueducts, and – some folks claim – Yankee Stadium too! They also used this stuff to keep false teeth in place and to give soda water that real thing – flavor. (As a matter of fact, cola with cement added is the "real thing".)

With all that use, the excess rocks were taken out of the market, a scarcity developed, and many a used-rock dealer became a millionaire. Their wives went around with large rocks cemented to bands on their fingers.

2. **Pure Honest Science.** – People kept searching for a better way to bind things together when building. They experimented with various materials. Finally, they found that special types of stones and lime, if ground, combined, and heated, produced an excellent cement. This product was called portland cement (after the Isle of Portland, in England). Thus from about 1800 on, portland cement has been used with excellent results.

Facts about portland cement:

1. Portland cement is not a trade name; it only means a certain type of cement.
2. Portland cement is sold in bags of 94 lbs. each. This is exactly equal to one cubic foot of powdered cement.
3. All portland cement is hydraulic. This means it will harden or set under water.
4. Portland cement acts as a binder when mixed with water. Water and cement when combined form a chemical combination, creating hard crystals that adhere to sand and stone and thus bind them together.

UNIT IV – MASONRY

Types of Cement **Lesson 8**

Objective:

At the end of this lesson the student will know about a number of different types of cements and their uses.

Related Information:

1. **Ordinary Portland** – normally used for general construction work such as buildings, bridges, roads, sidewalks. In other words, for average work.

2. **High Early Strength** – used where higher strengths are required at early periods. The strength of cement depends greatly on how fine it is ground. High-early is ground superfine. Thus it not only is stronger to start with, but it takes less water and hence is stronger and faster in setting and hardening. Hence, when a structure has to have excellent strength and go up fast – high early portland is the best buy. It also reduces the time required for protection in freezing weather. Yup – they use it for schools.

3. **Sulfate-Resistant** – used in construction where the structures are affected by waters with high concentrations of sulfates, such as sea water, water in certain manufacturing plants, or on certain ground areas with sulfates. Sulfate-resistant cement will not be weakened under these conditions.

4. **Aluminous-Type Cement** – used especially where concrete has to be used right away. Examples – sewers, airport runways, water mains, telephone installations or any other installation where repairs must be made as quickly as possible. This cement is made highly resistant to injurious ground- and sea-water by eliminating free lime.

5. **Air-Entraining Portland** – contains small quantities of a chemical which produces millions of tiny, well-distributed air bubbles. The addition of air improves the workability and increases resistance to thawing, freezing, and the bad effects of salt. It is used mainly in industrial construction.

SPECIAL-PURPOSE CEMENTS

1. **Mortar Cement** – usually made by combining normal portland and high-calcium limestone, or, simply stated, adding a small amount of lime to make the cement buttery, hence easier to work with. Mortar cement can be bought prepared or can be made by adding 10 to 15% lime to portland cement.

2. **White Portland Cement** – similar to regular portland in all aspects but color. It is made from specially selected ingredients to produce a pure white finish. It has the same strength as regular portland but has beauty in addition.

UNIT IV – MASONRY

Concrete **Lesson 9**

Objectives:

1. To understand the difference between cement and concrete.

2. To learn that cement makes possible a great variety of building products.

Short review:
In the previous lesson we learned that cement is a material that, when combined with water, will bind things together. Simply stated, *cement* paste is a *binder.*

Concrete is a combination of ingredients: a paste of portland cement and water, combined with sand and either gravel or crushed stone. The sand and stone (or gravel) have no ability in themselves to stick together; they are used merely as fillers. Once the cement paste is added, a chemical action transforms the mixture into concrete. This solid, hard mass all depends on the binding action of the cement paste.

Cement is such a versatile binder that a tremendous variety of building products is available – cement block, cinder block, brick, and structural, floor, and roof tile. Concrete poles for road signs, road tile and pipe, fence posts, septic tanks, lawn furniture, sidewalks, highways, curbs, bridges, ramps, walls, etc. – all are made with cement.

On your way home today, see how many different concrete products you can see.

Concrete Advice **Lesson 10**

Objective:

At the end of this lesson the student will understand more about concrete and how to handle it.

Related Information:

Once you have learned how to handle concrete, you will be the object of envy on the part of ordinary people. You will also be able to advise your "paw" how to install watering troughs for cattle, to weasel-proof hen-houses, build foundations for dog houses, footings for wine cellars, or a cement pit for sheep-dipping or barbecues. Win the admiration and friendship of your "pop" – act as his advisor.

1. Effect of air temperature on concrete

Low temperatures retard concrete's chemical action (hardening) and also cause concrete to lose strength.

Extreme cold or freezing almost stops hardening altogether and can ruin footings.

Best air temperature should be between 50°F and 70°F. If higher or lower, use protective measures (or don't do the job).

To prevent the soil and the footings themselves from freezing, use some protective insulating materials before and after pouring. Examples – straw, salt hay, other insulating materials, or some form of artificial heat.

Protect footings from freezing

Avoid rapid evaporation of water from concrete. If water evaporates too quickly, hydration (hardening) will not be complete. Wind, air temperature, and humidity all affect proper "curing." Conditions must be as nearly ideal as possible. Protect newly poured concrete from the hot sun. Dampen subsoil and forms and cover them. Slow evaporation of moisture is absolutely necessary for curing.

Protect concrete from drying too fast

2. **Using chemicals**

The chemical calcium chloride is sometimes used to speed up the setting time of concrete. It should not exceed 2 percent by weight. Chemicals *will not* prevent concrete from freezing. There is no such thing as a concrete antifreeze. The best advice is *Do not pour concrete in freezing weather.* If you must, then use every possible precaution before, during, and after pouring to keep it from freezing.

3. **Curing**

"Curing" means proper hardening (hydration). Proper curing depends on proper temperature and moisture. Unless you *absolutely* control these factors, the concrete strength is sacrificed.

4. **Placing concrete**

(Note: The word "pouring" is not used, as concrete should be used as stiff as possible). Mixes should be stiff, chutes should be smooth, and the concrete should drop no more than 3 or 4 feet. If the concrete drops from too great a height, stone "pockets," sand streaks, and separation of materials result.

5. **Water in concrete**

The principal function of water is to bring about hardening (hydration). *It is absolutely essential to avoid excessive water in mixing.*

Water for concrete must be clean and pure. A good rule to remember is – if it is fit to drink, it is fit to be used. Excessive impurities in the water can affect the strength, stability, setting time, and ability to withstand discoloration and deterioration.

UNIT IV – MASONRY

Controlling Surface Water **Lesson 11**

Objectives:

1. At the end of this lesson the student will understand why surface water collects next to a house.

2. He will know some common-sense remedies for this.

Related Information:

Controlling surface water around the foundation of a house is a perplexing problem to many homeowners. Let us make some simple observations in house construction and clear up any misunderstandings about this.

First Observation:
In excavating for a foundation, the excavation must be made larger than the size of the foundation. This is done to allow room for the forms and drain tiles, and also to allow room for the masons to work – installing the walls, waterproofing, and whatever.

Example:
An excavator using a bulldozer usually digs from front to back. Thus he must create a ramp or slope going in and going out, in order to keep digging deeper. Further, he must cut away the sidewalls of dirt at least 2 feet, to allow room for the workmen.

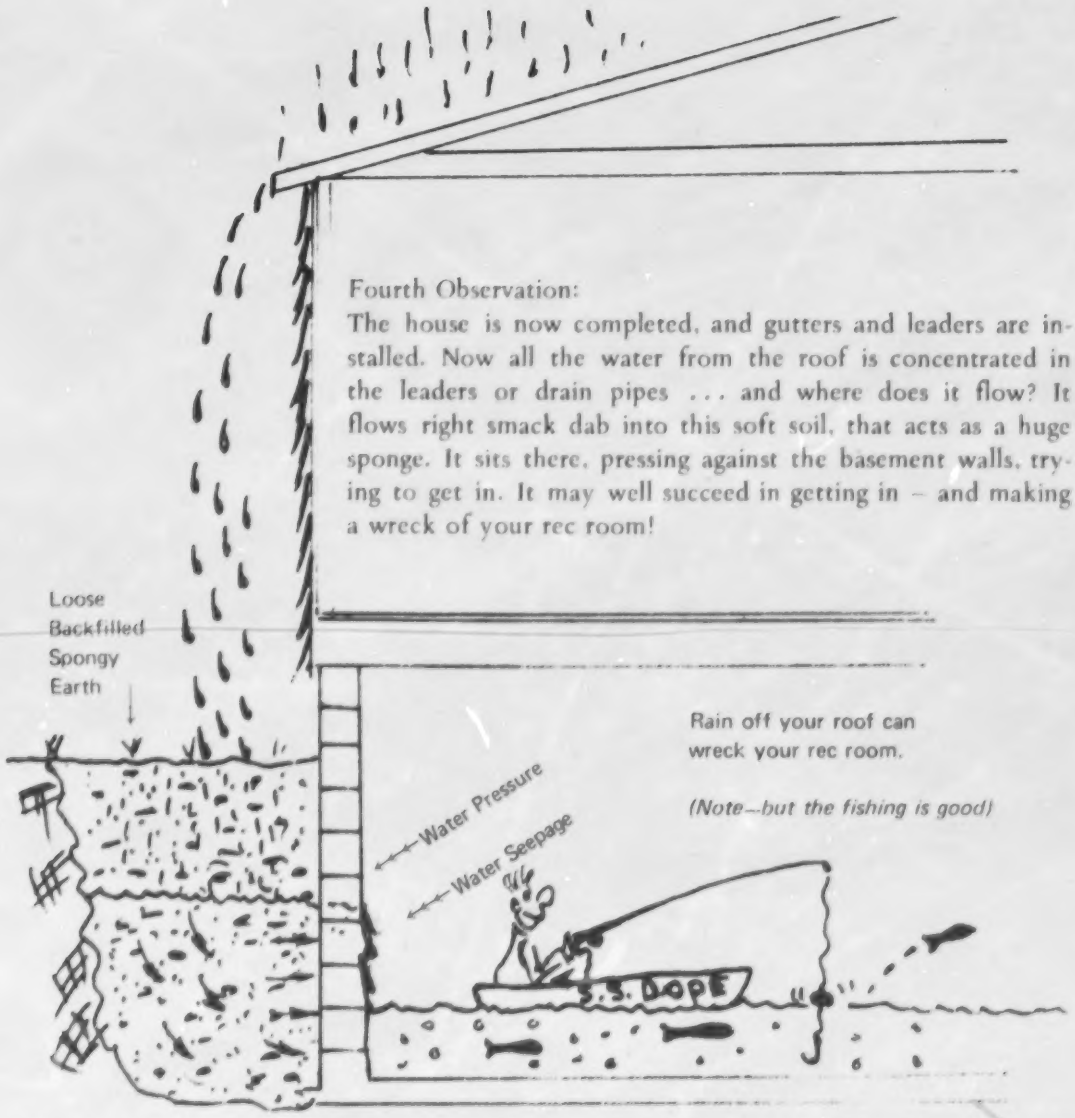
Therefore, huge volumes of earth are heaped about that are now well mixed with air and hence are less compacted.

Second Observation:
The original foundation site was solid, settled ground that nature had compacted for years.

A huge excavation is made in this solid ground, and a foundation is installed. When the foundation is complete, the dirt is pushed back (backfilled).

Third Observation:
Now we have a foundation surrounded by soft, spongy, air-trapped soil. The surrounding, unexcavated ground is firm, compacted soil.

Fourth Observation:
The house is now completed, and gutters and leaders are installed. Now all the water from the roof is concentrated in the leaders or drain pipes ... and where does it flow? It flows right smack dab into this soft soil, that acts as a huge sponge. It sits there, pressing against the basement walls, trying to get in. It may well succeed in getting in – and making a wreck of your rec room!



Rain off your roof can wreck your rec room.

(Note—but the fishing is good)

What's a feller to do? Well, Buster, the first thing to do is to *bridge the soft, spongy gap* between the drain pipe and the solid soil, which we trust is properly sloped to drain the water away from the house. To bridge this gap – which may vary from 3 feet to 12 feet – you need a *conductor* of some type. This requires a trough or some type of pipe at least the same diameter as the drain or larger. A 24" or 36" cement splash-block or a flagstone is a *joke!*

The next consideration is how to compact this loose fill without waiting 30 years or so. This can be accomplished to some extent by soaking or tamping this ground or both. This is to accelerate the work of nature. However, caution must be used, as water and tamping can create a pressure that could crack the walls. Soil should be added as the earth settles, to provide a slope for drainage away from the house.

A Do-It-Yourself Observation:

During or after a rain, check the drainage around your own house. Is it running off or collecting?

Waterproofing the Foundation **Lesson 12-(A)**

Objectives:

1. At the end of this lesson the student will understand the reasons for waterproofing a foundation.

2. The student will also understand some methods of waterproofing.

Related Information:

Soil is frequently damp or wet at normal foundation depths. The amount of water present around a foundation depends on many factors. For example, it depends on the amount of rainfall, the location of streams and lakes, the existing water table, and the composition of the soil.

Ordinary foundations, whether they are poured concrete or built of masonry units, are not absolutely waterproof. Some water can seep through the best constructed foundations. Therefore an ordinary basement can become a beautiful swimming pool.

The time to take preventive measures is when the foundation is being built. Waterproofing is relatively simple during construction, but extremely difficult after the house is finished. Thus, waterproofing is really preventive insurance that is well worth the extra cost.

The material density of poured-concrete or block foundations is limited. And even with the addition of waterproofing cement additives, the masonry is porous. Thus, this porous surface must be coated to seal it against moisture.

1. **Poured concrete foundations** Poured concrete foundations are superior in density and strength to block foundations, but still require waterproofing. One of the simplest forms of waterproofing for concrete is hot tar or asphaltum. Heated tar expands and flows easily, making application a snap. Remember – hot tar not only sticks to concrete but also to shoes, clothing, and human hide. It smarts, too, so be careful.

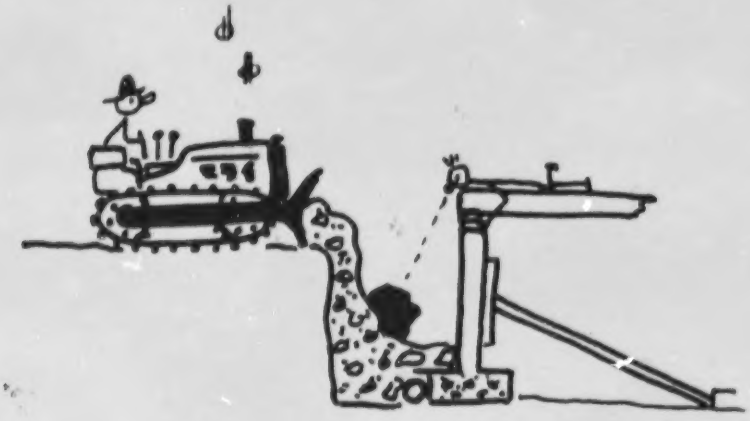
2. **Concrete, cinder, or composition block.** The foundation constructed of these materials requires greater precautions. Block construction involves numerous joints and the blocks themselves are a more porous material. (The wise student reads on and absorbs the facts; the fool is in hot and cold water all his life).

   Block joints should be neat, tight, and strong, and then a cement-plaster coat is applied as further sealing protection. A good job consists of two coats of plaster, so that the final thickness is about ¾ of an inch thick.

   The most critical point is where the foundation walls meet the footing. This juncture must be absolutely clean and be free of dust, mud, cement droppings, and debris. A cement cove or slope of fresh cement mortar should seal this juncture.

   Once the wall has been plastered and properly coved at the base, you are ready to waterproof. Now you can apply hot or cold tar by brush or spray. Hot tar is better because it is more flexible and sticks better.

   If the water conditions are excessive, you can apply rolled tar paper (felt) to the tarred wall and recoat again with tar. The amount of tar and the number of layers of tarred paper depend on the existing conditions.



Note: The best job of waterproofing can be undone by careless backfilling of dirt. Rocks and other objects can strike the tarred surface and break the seal. You don't have to be a scientific genius to see how important it is to do a good backfilling job. It's just common sense.

In recent years some builders have used a plastic sheet of polyethylene on the foundation instead of tar paper. It's like wrapping your foundation in a plastic bag.

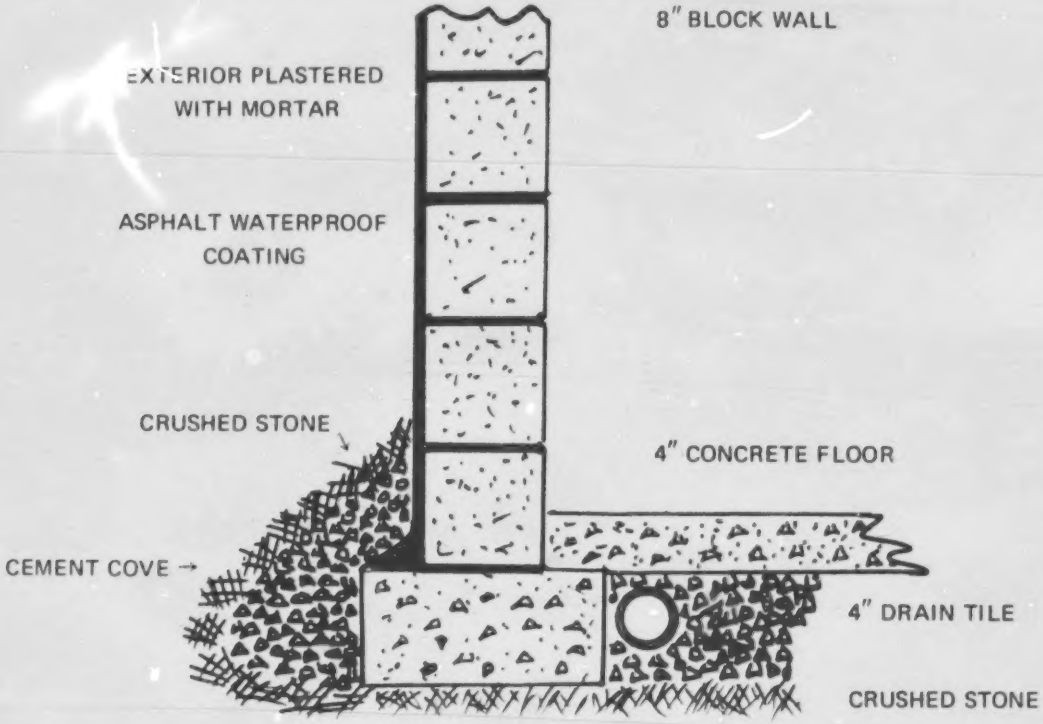
Waterproofing the Foundation **Lesson 12-(B)**

Objectives:

At the end of this lesson the student will know why and how to use drain tile.

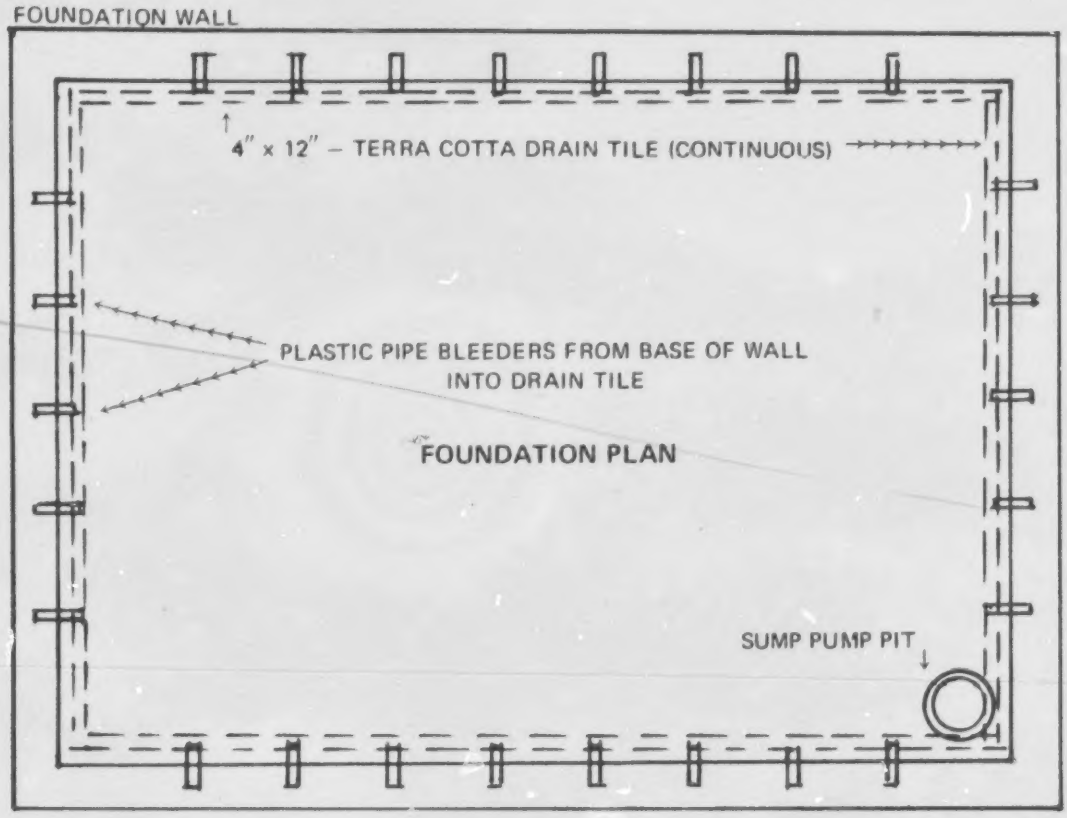
Related Information:

Are drain tile really necessary? That's like asking if boots or rubbers are necessary. Sure, they're not if the sun is shining – but suppose it's raining!



Well, the same with drain tile. You may not need them everyday. Maybe never. But, aren't they nice to have around "just in case"? Installation depends on the existing conditions and expected future problems.

You do not have to be told that water will always flow toward a low spot if it gets half a chance to do so. Where it is possible to run off accumulated water to a low point or a sewer, the drain tile should go on the outside of the foundation. As the drain tile are installed around the outside, they should follow a downward slope to take advantage of gravity. Thus the exit point should slope or pitch away from the bottom of the foundation, just as the surface area around the house should slope away from the house.


FOUNDATION WALL
4" x 12" – TERRA COTTA DRAIN TILE (CONTINUOUS)
PLASTIC PIPE BLEEDERS FROM BASE OF WALL INTO DRAIN TILE
FOUNDATION PLAN
SUMP PUMP PIT

If the foundation is below the sewer level or the drainage point, the tile can be put either inside the basement or outside. Remember, water can't run uphill, and so a pump is required. Thus a sump pit and a pump must be installed at the low point or exit of the drain tile. Most pumps are automatic and contain a switch and a float. As the water rises in the pit, it raises the float, which in turn activates the switch.

Folks with weak heads pump the water out of their foundations through a short pipe in the wall. Thus, as the pump expels the water, it flows right around the foundation and back in! The right way is to extend the pipe so that, as water is expelled, it will run off and away from the foundation.

A commonly used drain tile is a hard red clay tile called terra cotta. The best size is about 4" in diameter and about 12" long. These tile should be laid in or around the perimeter end to end, leaving a small gap between tiles. The gap is provided so that water can enter so that it can be channeled off. The tile should be laid on a bed of gravel or crushed stone at least 4" in depth. The tiles should not be placed above or below the concrete footing but on the same level. The tiles should be pitched toward one low point, and the joints covered with tar paper strips. The strips prevent cement or mud from getting in, but still permit water to seep in.

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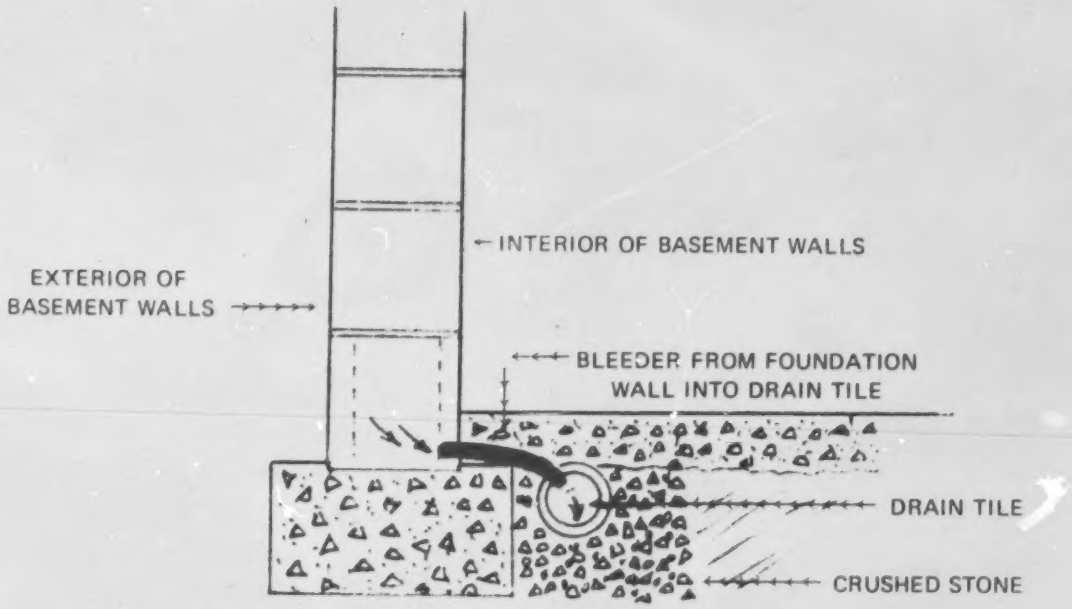
Drain tile placed on the interior perimeter should have short lengths of bleeder pipes spaced about every two feet. They should lead through the base of the foundation wall into the drain-tile system.



UNIT IV – MASONRY

Reinforcement Materials **Lesson 13**

Objective:

At the end of this lesson the student will be able to understand why and how reinforcement materials are used in concrete.

Related Information:

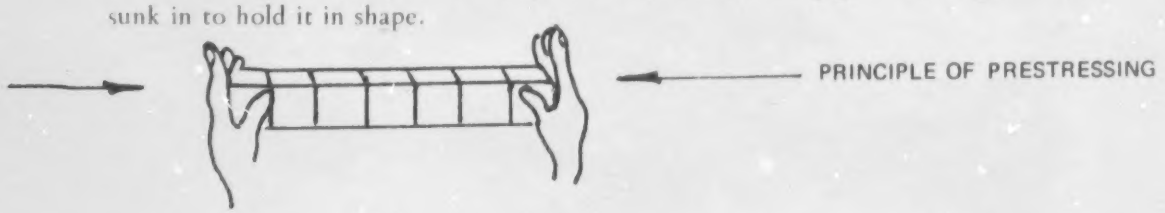
Concrete is a lot like a student – it has strengths and weaknesses. The trick is to offset the weaknesses and get both to work – and this calls for reinforcement! Let's investigate the weaknesses of concrete first.

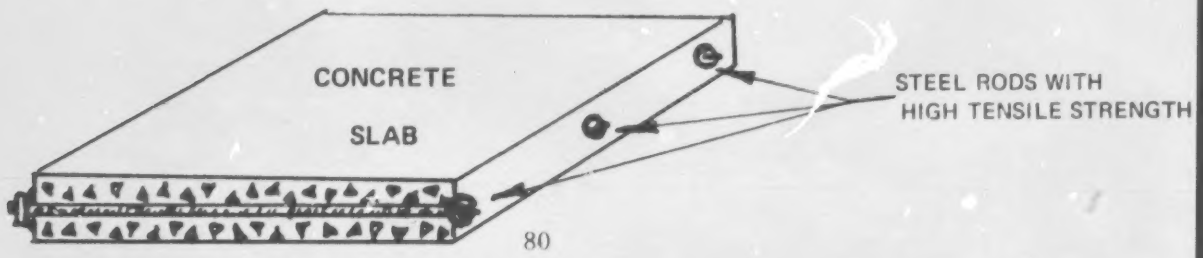
Concrete is much tougher than chicken feathers. It can withstand tremendous pressures and has a high resistance to crushing. Earlier, we called this compressive strength. But concrete has not too much tensile strength – it is a pushover for pulling apart or breaking, and that's where reinforcement comes in. To offset this weakness you have to add something that can withstand a lot of tension and stress – and what's better than steel? Yup, steel has high tensile strength and, when added to concrete, it gives concrete a high resistance to bending or pulling. Thus steel in various forms is added to building beams, bridge beams, floor beams, and slabs.

Reinforced concrete comes in a wide variety of forms, such as:

1. **Architectural concrete.** This is steel-reinforced concrete, cast in special shapes such as girders, roof decks, posts, and slabs. They actually combine beauty and strength and can be used indoors or outdoors without any further treatment. If you don't believe it, then play hooky and fly out to California and see for yourself.

2. **Pre-stressed concrete.** Some science teachers say it's like a woman in a tight girdle, but that's a poor example. It's really more like used chewing gum with big steel nails sunk in to hold it in shape.





Remember when you played with wooden blocks? Well, by putting a series of wooden blocks end to end, you could lift the whole bunch by squeezing them together. Pre-stressed concrete uses the same principle. A wire cable is stretched, positioned, and anchored into a form by hydraulic jacks. Next the concrete is poured around the cable and left to set. The cable anchors both ends and never lets go – just like squeezing the blocks.

3. **Reinforcement mesh.** This is a pre-formed wire mesh that a guy could use for eagle cages because it's so big. Well, it's imbedded in concrete slabs that are used as roads, sidewalks, runways, etc.

Foundations for Porches **Lesson 14**

Objective:

At the end of this lesson the student will appreciate the proper procedure in building on porches.

Related Information:

This lesson is important because poorly constructed porches are one of the main sources of a homeowner's headaches. How many times have you seen a porch pulling away or separating from the main foundation? Have you ever wondered why?

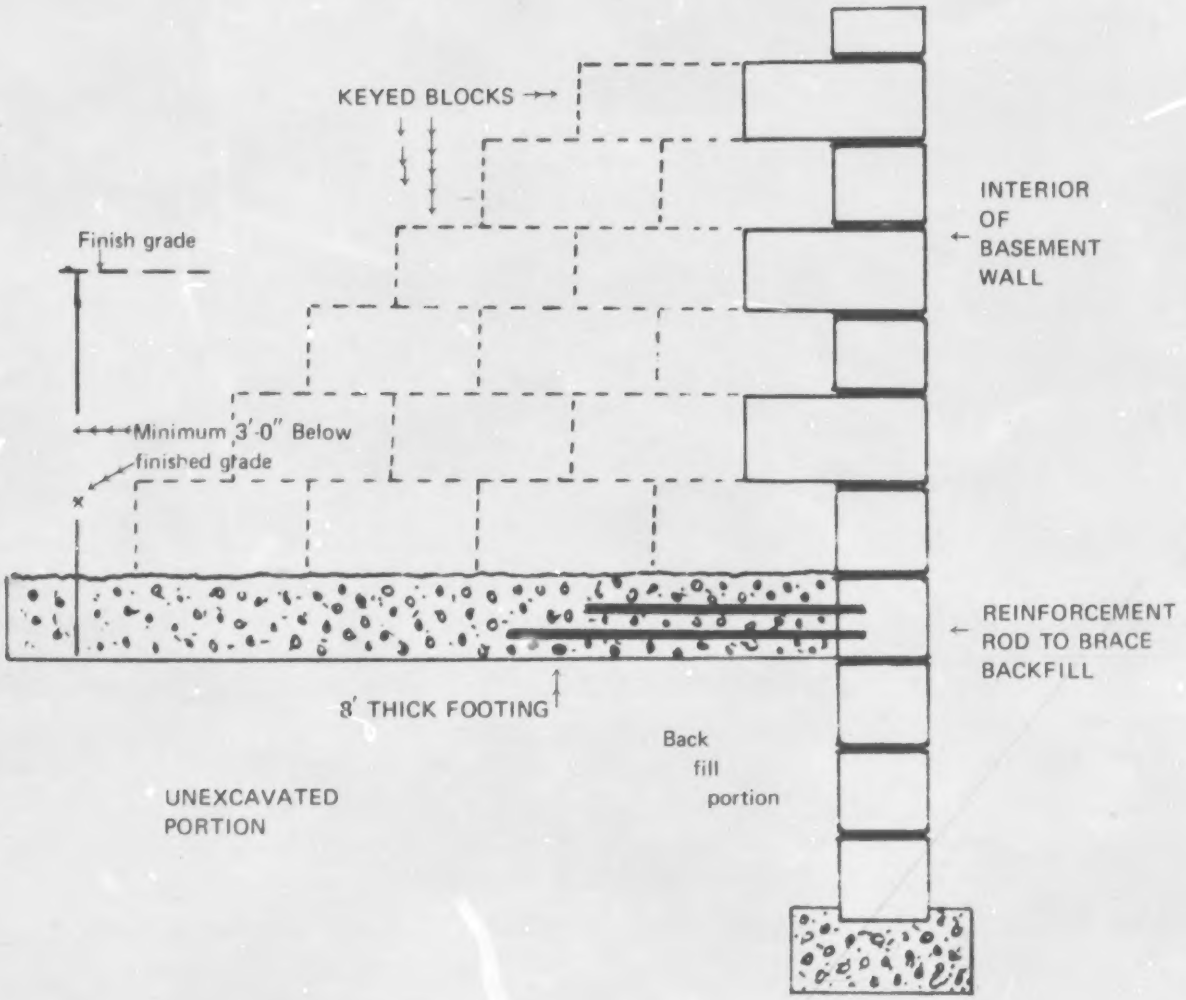
Well, this lesson will help explain some of the causes. So if you hang in, your porch will hang on. There's nothing worse than having your porch pull away while you're sitting on it.

Porches and masonry additions are constructed in two ways. Let's examine both methods.

A. Partially attached. This type of addition does not start at the main foundation level but begins slightly below the frost-line level (about 36" below grade). The mason inserts a block at right angles to the main wall where the planned porch begins and ends. He will repeat this procedure on every other row of blocks on the main wall. Thus a series of blocks juts out at the porch location, to act as a future key. The porch area is excavated and a U-shaped footing the size of the porch is installed. Blocks are then laid to interlock with the wall keys and – presto! you have the rough outline of a porch. When completed, the porch consists of a series of steps and a hollow platform. This platform is usually filled with dirt, and the porch slab is poured and set. Naturally, precautions are taken to settle the dirt, and reinforcements are inserted into the porch slab.

B. Totally attached. This method requires that all additions start at the same footing (base) level as the main foundation. Thus the main foundation and any porches, etc., become one big continuous footing.

The foundation walls of the porches are erected in one continuous fashion with the main foundation, and it makes a super job. This one-piece interlocking masonry unit is then cement-plastered and waterproofed. Its chances of pulling away are mighty slim. Usually an opening is provided in the main foundation, providing an access for additional storage room. This little room makes an ideal wine cellar or a place where students can hide from their parents.



Study the chart that follows and see the advantages and disadvantages of each method. Knowing these facts can help you considerably in any future building plans or even in repairing existing problems.

METHOD A	METHOD B
Requires less material.	Requires more material, but very little more.
Requires more work – trenching, footings, backfill.	Faster and cheaper to prepare because excavation is all done at once.
Tendency for fill dirt to settle, creating repair problems.	Requires no fill dirt.
Can break off and pull away. Footing defects and difficulty in interlocking.	Continuous, interlocking walls eliminate pulling or breaking away.
Filled-earth porch a constant problem with termites, insects, and rotting.	Virtually termite proof.
Difficult to properly waterproof.	Not affected by surface water or weather to any appreciable degree.
Effective repairs are very difficult.	Provides additional storage space.

Note: With all costs considered, the two methods cost about the same.

To Do: Select the method you think is better and write down the three reasons you think are most important for your choice.

UNIT IV – MASONRY

Interdependence of Trades **Lesson 15**

Objective:

At the end of this lesson the student will understand that masonry is everybody's business, and that all trades should learn the basic facts.

Related Information:

A basic knowledge of masonry is helpful to all tradesmen, as each trade depends to some degree on another. There are many occasions where you have to know something about another trade to accomplish your own. The following are some honest-to-goodness examples from real-life experiences.

Example 1. A carpenter, for example, must know how to erect forms for footings and walls. Other tradesmen, such as electricians, plumbers, heating men, and others, must frequently go under, through, or over masonry units. They must know something about masonry because the building code or safety require that structural strength must be maintained.

Example 2. Piping for water, gas, and sewer must pass through or under masonry units, and the tradesmen involved must know right from wrong. A few simple errors can affect the structure for its entire life.

Example 3. Carpenters must attach wood sills to anchor bolts on the foundation, girders to piers, and other wood to masonry joints. Thus, some knowledge of masonry is necessary to avoid errors or damage.

Example 4. Air-conditioning and heating mechanics must at times install controls, piping, and duct work on, over, and through masonry units. Thus, despite all the plans and specifications in the world, tradesmen must know some masonry facts to communicate and cooperate with each other.

Summary: Just picture the many things in a house, such as windows, doors, appliances, supports, anchors, or bases that involve masonry Another point – workmen from all trades are advanced to positions of supervision. Thus a masonry background is very helpful.

Now, there are some persons that dislike all types of cement and water and are slightly antisocial to boot. This type is only friendly to masons when they want to swap lunches or borrow a steel trowel to slice some salami or cheese. Now masons are a tightly knit group and are honor-bound to stick together like cement. They can pass the word down, and then, Buster, watch out! Suddenly lunch pails, shoes, pockets, and other hollow objects get filled with stuff called concrete. *It pays to be friendly and cooperative.*

Masons are a closely knit group

UNIT V – FRAME CONSTRUCTION

Following the Plan **Lesson 1**

Objectives:

1. At the end of this lesson the student will realize the importance of following the plan.

2. The student will also realize that errors occur and know how to use good judgment if they do.

Related Information:

Planning is an essential ingredient of almost every human activity. For example, a simple thing like a trip to the store requires some plan. Without planning your route you could take the wrong road, and you might wind up throwing rocks at some teacher's house.

Building a house requires that you follow the plan, so that the finished product is an exact reproduction of the drawing. If you want to nail a bunch of boards together for squirrels to run up and down looking for the nut that built it – *don't* follow the plan.

Now, as your leader I'm telling you to follow the plan. Because the entire structure is dependent upon the accuracy of the lay-out of the floor, walls, room partitions, and roof. Inaccuracy would cause confusion in every trade that follows, and it would result in a hopeless mess.

Perfection, on the other hand, is sometimes impossible to reach. Thus tiny errors are common, and this margin of error must be recognized.

For example, the spacing between studs or floor joists might vary a whiz. Wherever possible the errors in measurement should be corrected. In other cases, where the error will not basically alter the design or strength, it may be allowed to stand. A serious error must be corrected, because all that follows will only extend the error, and the design or strength is affected.

Short Classroom Drama

Innocent Student: "You mean that folks can make mistakes and get away with it? '

Truthful Teacher: "Yes, minor mistakes that can be corrected or do not affect design or strength are allowed. Remember that we can learn through mistakes. Most folks except teachers make mistakes. Teachers never make mistakes, and don't you ever forget it."

Innocent Student: "Yup"

To minimize mistakes in layout, you should use a steel tape and a sharply pointed pencil. Do *not* use a 6-foot rule and keep sliding it. This can cause you to gain or lose, and the error can be substantial when you reach the other end of the house. The steel square must also be accurately spaced off and measurements marked with a sharp line to avoid errors that may add to each other. Check all dimensions against building plans for accuracy. Errors do occur in building-plan dimensions; if you find any, notify your supervisor or architect.

When the decision is entirely yours, decide which area would gain most by the gain or loss. Determine how to make the correction where it would least affect design, strength, or other trades to follow.

Errors in critical areas such as the bathroom can be serious. For example, errors can lead to a bathroom door's not being able to open fully. The door may strike a fixture and create a problem for entry and exit.

Once upon a time a foolish person did not follow the plan and created a large error. The only way you could get into the bathroom was through a laundry chute in the wall. The door was not a complete loss, because it was used as a bulletin board, but entry to the bathroom was mighty inconvenient.

UNIT V – FRAME CONSTRUCTION

Carpentry Specifications **Lesson 2**

Objective:

At the end of this lesson the student will know that specifications are of extreme importance and why they are.

Related Information:

Specifications are necessary because it is virtually impossible to include all the tiny carpentry details and explanations on the plan itself. If all details were included, the plan would be so confusing that even the fellow that did it wouldn't understand the plan.

Thus carpentry specifications act as extra explanations in writing that spell out all the small details impossible to include on the plan. They supply the information on grades of lumber, type of lumber, spacing of members, etc. They also include the quality of work to be performed. Specifications add to the blueprints as follows:

1. Supply additional information to fully explain plan.
2. Detail the grades, sizes, quality, and even (sometimes) brands of materials. They eliminate mistakes and guesswork regarding all of these.
3. Help in estimating costs of labor and material.
4. Help prevent disputes between owner and builder.
5. Serve as a guide for all trades (no passing the buck).

When your teachers give verbal or written instructions, they act as specifications, and you are aware of what is expected. It's hard to swallow sometimes, but it's good training for on-the-job requirements in any trade. Would you want to live in a house built any old way, or in one that was designed to fit your needs? It's as simple as that.

Building specifications usually give information as regards permits, insurance, liabilities, contract payments, changes, substitutions, and supervision. Specifications are an important part of the contract, and in most cases more important than the plans. This is true because plans can be changed or corrected, but specifications cannot be changed without breaking the contract. Most folks think the plans are the most important part – the bible of the building trade. No way – it's the specifications.

UNIT V – FRAME CONSTRUCTION

Types of House Framing **Lesson 3**

Objective:

At the end of this lesson the student will know the difference between the two basic types of framing.

Related Information:

The frame of a house consists of a collection of lumber with special names, such as sills, floor joists, girder, studs, rafters, and braces. When these framing members are placed and secured in a certain way, they form the skeleton of a house.

Guess who invented house framing? Would you believe it was a bunch of cave kids? Well, it's true, but history books have never been kind to kids, and so it's a little-known secret. Here, revealed at last, is the true story - one that until now parents and teachers have managed to keep out of the history books.

Once upon a time a bunch of kids got together and started to build a tree house. It wasn't perfect, but it beat playing in the damp, dark caves they lived in. The construction went on for several days before it was noticed by one of the parents. Then, just by chance, a parent looked up and spotted this framing beauty. He turned to his wife and said "Hey, maw, I think the kids have got something!" And that's how it all started.

There are two main types of framing generally used: the platform or western construction, and balloon framing. The earlier balloon-type framing relied on the available wood science of that time. It was known that the greatest wood shrinkage occurred in width and thickness, and the least amount of shrinkage in length. Hence, early framing relied on vertical supports with elaborate bracing. This vertical framing was so rigidly braced that sheathing was not relied upon for bracing.

Modern science, a demand for more housing, and a demand for safer working conditions helped to bring about platform construction.

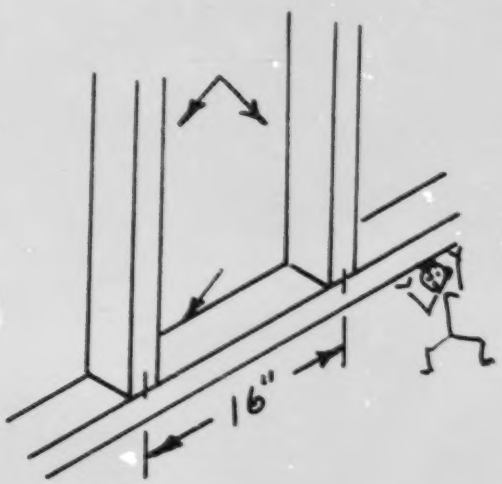
Wood science rapidly improved the growing, cutting, drying, and the variety of wood products. Wood technology improved methods of cutting logs, producing stronger and better lumber. Drying out excessive moisture in wood was now controlled by huge ovens instead of open-air drying. Thus lumber was dried faster, increasing both quality and volume.

This new lumber technology made **platform framing** possible. Now framing could be horizontal, because the shrinkage could be better controlled. Uniformly spaced vertical studs replaced the heavily braced vertical framing, and modern sheathing compensated for the reduced bracing.

Thus platform framing permits more uniform settling and shrinkage. It also simplifies material sizes and provides a stronger, safer, more fire-resistant framing.

Basically, platform framing consists of a large, boxlike platform that resembles a movie stage. The exterior and interior walls are erected as separate frames on this stage and raised into place. Then structural members called celling joists are uniformly spaced on the raised walls. This acts to tie in the whole upper portion and also provides a nailing base for the ceiling. Finally, roof rafters are added to form a sloping frame.

Most framing is uniformly spaced 16" on center, which means from the center of one framing member to the center of the next.



UNIT V – FRAME CONSTRUCTION

Characteristics of Wood **Lesson 4**

Objectives:

1. At the end of this lesson the student will understand how important wood is in construction.

2. The student will also understand how and why lumber is seasoned, and which variety is most widely used in the East.

Related Information:

Wood has been the basic construction material from the dawn of history. In all parts of the world, trees, logs, branches, and leaves have been used to shelter man. Early settlers in this country used wood in the form of logs as the basic construction material for their log cabins. The big question is – why was it used in early times and why is it still used?

First of all, wood has always been plentiful and always readily available. All a guy needed was a strong back and a sharp axe. Wood also was popular because it could be easily cut, shaped, drilled, and fastened; in other words, the workability of wood has made it one of the most important basic construction materials.

Wood is not only plentiful and easily worked, but it also possesses great strength, durability, and beauty. Each type of tree produces wood with certain characteristics, and man by trial and error has been able to identify these qualities. Thus, as different woods vary in strength, texture, grain, and workability, they vary in their use.

The versatile nature of wood makes it adaptable for use as heavy beams or tiny bits of house trim and everything in between. Just picture the uses – framing, flooring, siding, roofing, paneling, plywood, trim, etc.

Wood in standing trees contains a great deal of moisture; it must be dried to prevent warping or shrinking. Wood used for framing and rough purposes does not need as exacting drying as does wood used for interior-finish lumber.

There are two methods for drying or seasoning lumber – air drying and kiln drying. Air drying takes about a year, because the temperature and moisture vary so much with the weather. The lumber is stacked in layers separated by wood strips, to allow air to circulate and dry it. It must also be protected from rain and from direct sunshine. Too-fast drying results in warping or checking, and so air drying must be slow and uniform.

Kiln drying is a quick way to season lumber. A kiln is a specially built room in which the temperature and humidity can be controlled. The first step in kiln drying is to expose the wood to live steam, so that all the wood has a uniform moisture content. Then the room is heated to between 140 and 160 degrees Fahrenheit for several days or a week.

Drying of any type reduces the tendency to warp, twist, or shrink. Drying reduces the weight of lumber up to 50%, thus making it less expensive to handle and ship. All framing lumber should be well seasoned and should have a moisture content not above 19%. Trim and millwork must be kept below 10% moisture content.

Many different types of wood are used for framing, but Douglas fir is the most popular on the Eastern Seaboard. It's fairly light and extremely strong and durable. In proportion to its weight Douglas fir is the strongest wood for framing purposes. The structural grades of Douglas fir have a tendency to check or split, but once the frame is covered it holds up well. The outer portions of the Douglas fir tree make the finest grades of lumber for siding, door frames, ladder rails, and interior trim.

Grades of Framing Lumber **Lesson 5**

Objective:

At the end of this lesson the student will know how framing lumber is graded.

Related Information:

Lumber is a lot like kids – it comes in a great variety of sizes, shapes, textures, and strengths. When you observe kids up close, you will see that they come in different colors, shapes, and sizes. Some folks called teachers even go so far as to say that they differ in their ability to do different kinds of work.

Selecting the right type of wood and the proper grade will save money and turn out a better job. This lesson is a shortcut course on the basic types and how they are used. The following report was submitted by a vocationally trained carpenter who graduated in the top third of his class, so pay attention.

Lumber in the forest is generally divided into two categories – softwood and hardwood. All trees that have needles or scalelike leaves – like pine, cedar, spruce, or fir – are classified as softwood. The hardwoods come from the broad-leaf trees such as oak, maple, ash, etc.

Softwoods are used most for general construction, and the hardwoods are generally used in cabinets, trim, moldings, and furniture.

All lumber is graded according to standards set up by an industry-government group. Grades vary greatly in quality and price. The following is a thumbnail sketch – the rest you will learn through shop and practical experience.

(A thumbnail sketch)

Lumber as it comes from the sawmill is divided into three main groups: yard lumber, structural lumber, and factory and shop lumber.

Yard lumber is lumber primarily intended for general building purposes. Yard lumber is less than 5" thick and is used for house building and light commercial structures.

Structural lumber is lumber 5" or more in thickness and width and is used primarily for heavy construction –bridges, ramps, barriers, and industrial structures.

Factory and shop lumber is lumber intended for further manufacture. It usually contains large defects that make it unsuitable for house framing, but bad spots can be cut out and it is suitable for many manufacturing purposes.

Since we are concerned with building, this part of the lesson will deal with yard lumber. Pay attention and get double benefits – high marks and keeping splinters out of your hide.

1. **Select lumber** – Select lumber is high-quality lumber of good appearance and finishing. Quality varies, and so it is classified into the following grades:

   Grade A – Practically free of defects and suitable for natural finishes. Used as exterior and interior trim or finishing material.

   Grade B – Allows a few small knots, but generally clear.
   Suitable for high-quality natural finishes.

   Grade C – Allows a limited number of defects that can be covered by paint.

   Grade D – Allows any number of defects which can be covered with paint without detracting from appearance.

Note: Select lumber can be used in house construction where good appearance and finishing are desired, especially for trim or decorative purposes.

2. **Common lumber** – A type of lumber that is suitable for general construction and utility purposes. It can be identified by the following grade names:

   No. 1 Common – This type is suitable for use without waste. It is sound and tight-knotted stock where the size and number of defects are limited.

   No. 2 Common – Allows large and coarse defects but is same general quality as No. 1. Used for framing, sheathing, etc. where stress and strain are not a great factor.

   No. 3 Common – Permits greater waste. Has greater number of defects and hence has limited use. Used especially for form work, rough flooring, etc.

   No. 4 Common – Low-quality, permitting coarse defects, decay, and holes. Very limited use in construction if used at all. Used for roof and sheathing boards and for boxes and crates.

   No. 5 Common – Not recommended for construction. Used for boxes and crates.

Starting the Framing **Lesson 6**

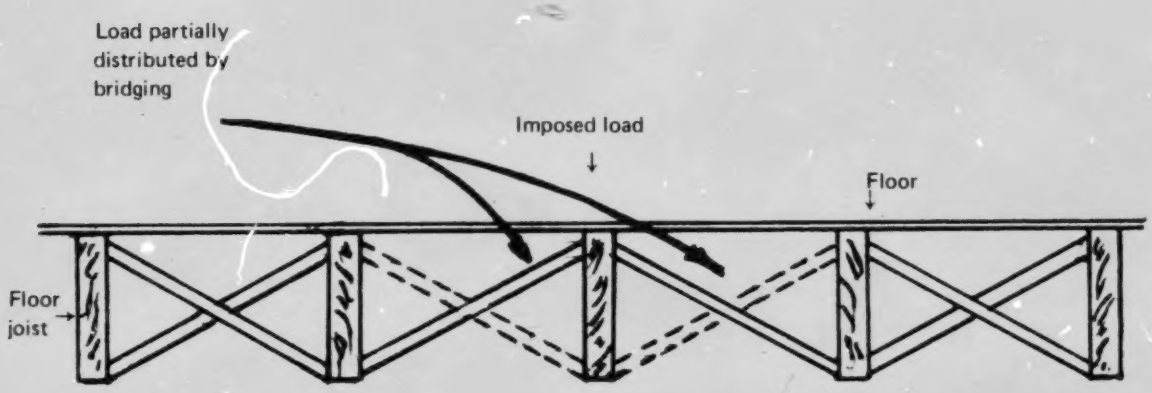
Objectives:

At the end of this lesson the student will be aware of many important rules used in constructing a platform.

Related Information:

Any kid that has built a treehouse with snitched lumber knows that you have to start with a sound platform or base. Well, a house that people live in has to start the same way, only much more so. To be sound, platform construction must follow certain rules:

1. The platform must be perfectly *level* to keep the rest of the house from leaning, twisting, or distorting. In place of *shims* we use a bed of cement or some material of a permanent nature. Wood or similar shims will only rot or crush and fail to level the load.
2. *Iron bolts* must securely fasten the wood to the masonry, to keep the house fastened to the foundation.
3. A large support of wood or iron called a *girder* must take the place of a supporting wall for the floor joists on long spans. The girder also supports the weight of the structure, plus any loads placed on the floor. Thus, the factors of stress and loads must be considered at all points. The girder alone actually supports one-half of the weight of the floor. The foundation walls together support the other half. Thus the girder carries a critical load.
4. Framing members called *floor joists* are spaced 16" on center to help distribute any load. The building code or a framing guide will recommend the proper size joists for a given span. It is necessary to double all floor joists around all openings and also where the partition walls above run parallel to the joists. This is a reinforcement for all points of stress.



CROSS BRIDGING

5. Small pieces of wood called *bridging* are placed diagonally between the joists to distribute the load imposed on one joist to the joists on either side.
6. *Plywood* is frequently used for the rough floor or deck because the cross-lapped layers are highly resistant to swelling or shrinking. Thus, plywood furnishes a strong, smooth surface and keeps the platform distortion at a minimum. Plywood minimizes the number of joints and is stronger than separate floor boards. Lumber, like most other things, shrinks when it dries out. It does not grip nails so tightly that were driven in when it was green. Tests show that nailing in green lumber has 25% less holding power than nails driven in dry lumber. Thus *kiln-dried lumber* not only minimizes shrinkage but permits stronger nailing.

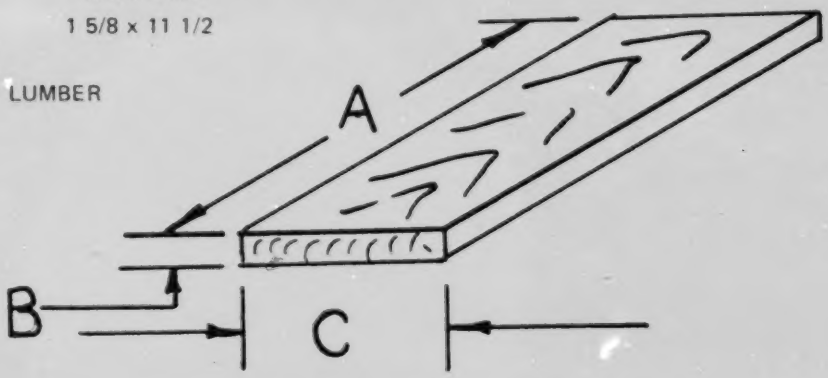
Other Facts About a Platform:

1. Plywood sheets are always lapped at joints to give added strength.
2. Plywood uses exterior types of glue for binding so that the plies resist separation.
3. Plywood's built-up layers provide greater nail anchorage than conventional lumber.
4. Special nails with a rosin coating are used for nailing down plywood, as the extra friction of the rough coating makes the nails hold super-tight.
5. Only a good grade of dry lumber should be used for platform construction, to avoid excessive shrinkage, distortion, and deterioration. Lumber should be protected in transit and on the job from rain and should be stacked so as to permit free circulation of air.

SPECIFIED SIZE	ACTUAL SIZE
2 x 4	1 5/8 x 3 5/8
2 x 6	1 5/8 x 5 5/8
2 x 8	1 5/8 x 7 1/2
2 x 10	1 5/8 x 9 1/2
2 x 12	1 5/8 x 11 1/2

NORMAL SHRINKAGE OF LUMBER

A – No shrinkage
B – Little shrinkage
C – Greatest shrinkage



UNIT V – FRAME CONSTRUCTION

The Purpose and Design of Exterior Walls **Lesson 7**

Objectives:

At the end of this lesson the student will know the basic function and design of frame walls.

Related Information:

Exterior walls have many functions, so let's examine a few and see if you agree with all of them.

1. An exterior wall should have *structural strength* so that it can support the load of ceiling and roof framing, plus the added weight of water and snow.

2. The exterior walls must also act as a *framework* so that covering materials such as sheathing and siding can provide a weatherproof covering.

3. Exterior walls also provide *privacy* for the folks who live in the house.

4. Exterior walls are necessary so that the necessary *wiring, piping, duct work,* and *insulation* can be installed within them.

5. The exterior walls also provide a structurally braced frame that can provide *strong openings* for windows and doors.

6. Exterior walls furnish a framework for the attachment of *interior wall-coverings* that make a house "livable."

Standard construction for walls

Residential construction consists of a wall made of 8′ lengths of 2″ x 4″ lumber, which are usually spaced 16″ on center. Why should we use 8-foot 2x4's spaced 16″ on center?

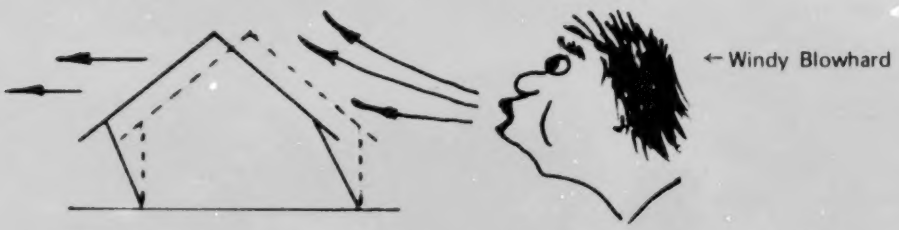
Well, smart-aleck kids have been asking this question ever since detention and report cards were invented. This is where kindly and friendly teachers fill the education gap – so sit up straight and pay attention – or else!

Both by trial and error and by scientific testing, the 2x4 stud has been found to be both safe and economical for framing. The 2x4 studs spaced 16″ on center can support the load and provide a strong framework.

The 16″ spacing permits the use of standard widths and lengths of sheathing materials and siding. The stud spacing further provides for insulating, electrical, plumbing, sheet-metal and heating materials. The 2x4 wall system thus provides strength and convenience, plus the important factor of speedy erection.

And Furthermore . . . . .

A most important point: we must *distribute all loads to framing members capable of bearing them.* Thus, an opening in the wall for a window or a door must be compensated for by using a header and doubling the studs. In that way no strength is lost despite the opening. Braces are used to rigidly maintain plumb (a true vertical position). Walls that can be twisted or distorted by the wind or the imposed load are never truly safe. Try balancing a ruler on your finger when your finger is not on dead center. The same applies to studs and walls.



STRUCTURE WITHOUT BENEFIT OF BRACING CAN BE DISTORTED BY WINDS

STRUCTURE WITH DIAGONAL WIND BRACES RESISTS DISTORTION

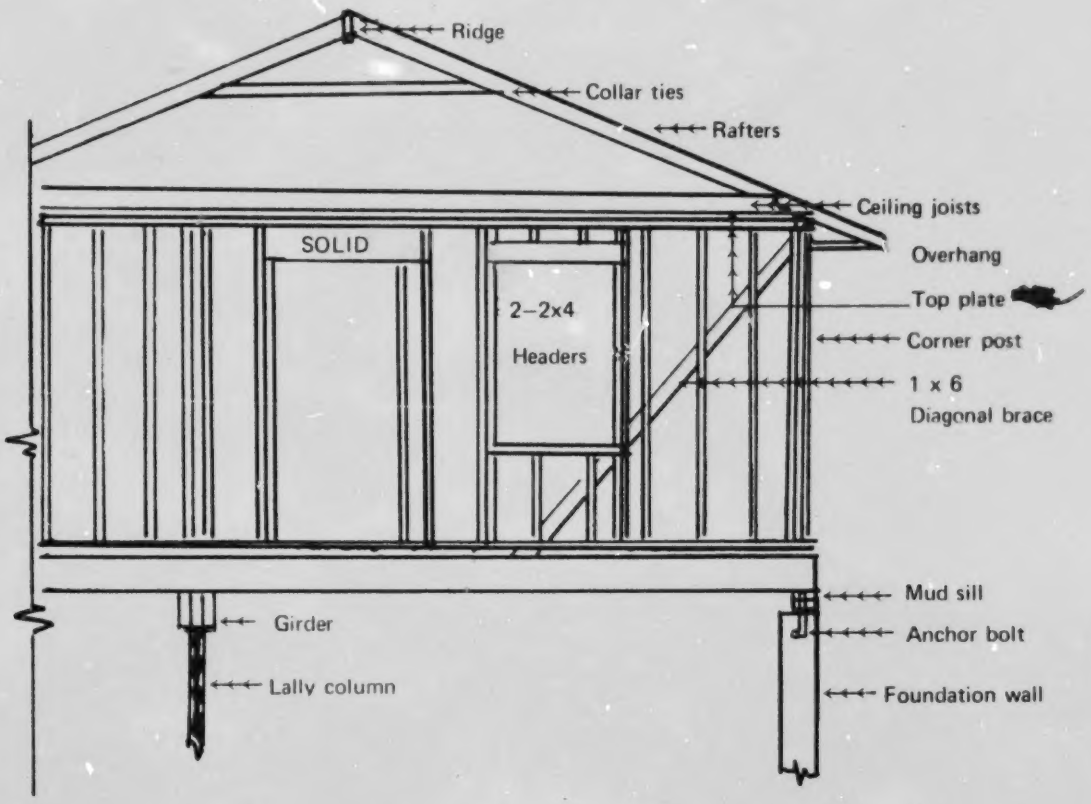
In Summary:

Framing on 16″ centers and using 2x4's provides an adequate and safe vertical framing to support the house load. Anything less might prove deficient under stress.

The A B C's of Building a Wall **Lesson 8**

Objective:

At the end of this lesson the student will know the A B C's of framing a wall.



Related Information:

To build a typical frame wall you would need the following materials:

A. 3 Plates (2x4's cut to length of wall)
B. The required number of precut studs
C. Wood header (for door or window opening)
D. Jamb studs
E. Plan (drawing or written instructions)
F. Diagonal bracing (1x4)

Framing Techniques

A. **Plates.** – A top and bottom plate are used so that the studs can be properly spaced and held secure. This is absolutely necessary. The top plate is usually doubled. This straightens and stiffens the wall. The uppermost plate is lapped at each corner, which further adds rigidity.

B. **Studs** should be reasonably straight, strong, and dry. They should be uniformly spaced to distribute the bearing load to avoid points of excessive stress.

C. **Headers** are used to span window and door openings. They compensate for the missing studs and distribute the load. As the span increases, the depth of the header must increase to take the extra load.

D. **Jamb studs** act as additional support at an important point of stress. They are installed in one piece from the header to the bottom plate. They thus act as a double stud and support the load placed on the header.

E. **Diagonal braces** are installed in each corner and oppose each other. They keep the frame correct and stiff and further protect against wind and other external forces.

Note: Throughout the framing is the underlying principle of *equal distribution of stress and strain.*

Assignment:

1. Using a wall kit, label each framing member. (Note: refer to sketch for proper labeling).

2. Start to assemble wall kit as per layout marks and as per sketch.

Bearing and Non-Bearing Partitions **Lesson 9**

Objective:

At the end of this lesson the student will know the basic difference between a bearing and a non-bearing partition.

Related Information:

Partition walls are any walls that divide the inside space of a building into rooms. There are two types of partition walls: the bearing wall and the non-bearing wall. The bearing type of partition supports the ceiling joists and any weight placed on these joists. In the case of a two-story structure, the bearing partition carries the weight of the second-floor joists and the weight of the structure above it. Thus a bearing partition is a critical area because it carries a load placed upon it. The bearing partition is usually placed in the center of a building or reasonably close to a supporting girder.

You can see, therefore, that the bearing partition must be constructed with the greatest accuracy possible. The studs should be strong and straight and be accurately spaced. All openings must have proper-sized headers, and all openings must be double-studded.

Thus, properly constructed, the bearing partition will carry an evenly distributed load. Any shortcuts in the construction or installation of a bearing partition may result in wall cracks, sticking doors, and uneven settling of other framing parts.

A non-bearing partition supports only itself. Nevertheless, care must still be exercised in framing it. Partitions that run parallel to the floor joists place their entire weight along one line. Thus floor joists should be doubled under all partitions that run parallel with the joists below.

Thus the science involved in constructing these two types of partitions amounts to common sense. There is a load or weight factor, and it must be compensated for. Failure to recognize this simple fact will shorten the life of the building or require extra expense in maintenance.

The mighty "if" can also affect the structural strength of any partition:
1. *If* the studs vary in length, due to careless cutting . . .
2. *If* the nailing splits the wood or fails to firmly hold . . .
3. *If* the studs are not perfectly plumb . . .
4. *If* the headers for openings are poorly designed, constructed, or installed.

Summary: You can supply the finest materials that money can buy, but unless you supply the simple know-how involved, the structure will always lack quality.

UNIT V – FRAME CONSTRUCTION

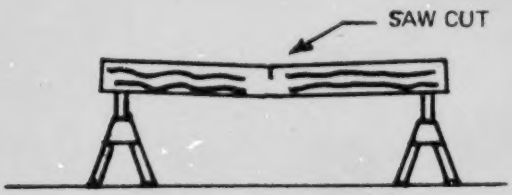
Cutting and Drilling Through Framing Members **Lesson 10**

Objectives:

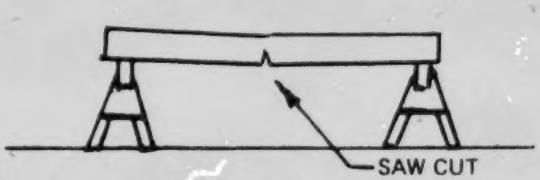
At the end of this lesson the student will know where cutting and drilling of framing stock will reduce strength the least.

Related Information:

If you placed a 2x4 edgewise on two saw horses and started cutting it in the center, the saw would soon bind. This binding is due to a *compressing* force at the top of the 2x4. However, if you cut the bottom of the 2x4 instead, the cut would open because the *tension* would pull it apart.



Board binds on top
(Top is in compression)

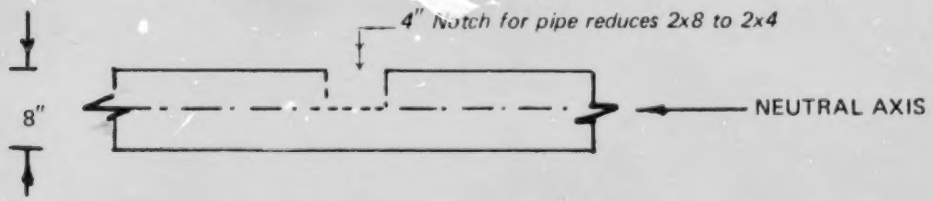


Tensile strength is lost

Thus the top of the 2x4 is in compression, while the bottom is in tension. However, there is a neutral point between the top and bottom of rectangular wood. Scientific investigation reveals that if you cut a hole in the center of the beam it will have very little effect on the strength of the beam. But hold it, Buster – science also reveals that the hole should not exceed one fourth of the total width of the beam. Make a bigger hole and you are in for trouble, because you are cutting the important fibers at the top and bottom that are affected by compression and tension.

Weight is also an important factor, so avoid cutting holes near the center of the board *span*. It is at the center that the weight of the beam exerts the greatest downward force. Thus try to make any holes closer to walls than to the center of a horizontal member.

Bathroom joists carry an extra load, because they carry the weight of plumbing fixtures plus tile. As before, cut holes as near as possible to the neutral point and avoid the center of a span. Should notching in the top of a beam be required – for a large pipe, for example – be prepared to do some extra framing to compensate. You should realize, for example, that if a 2x8 joist is notched 4" deep, it is no longer a 2x8 but a 2x4.



Bearing partitions are another critical area where you just can't hack away. Drill or notch the absolute minimum, and here again try to stay in the neutral zone. Excessive cutting will have to be compensated for by installing steel mending plates or special framing supports.

Cutting or weakening any structural framing member may weaken the frame. Apply the science you have learned, use some common sense, and ask questions That way you are bound to do the right thing.

UNIT V – FRAME CONSTRUCTION

Reviewing the Scientific Principles in Frame Construction **Lesson 11**

Objective:

At the end of this review lesson the student will have reinforced the scientific principles covered so far.

Question 1: Why must lumber used in construction be dry?

Answer: Moisture, when excessive, causes warping, twisting, and distortion. Green lumber can cause cracks in walls, sticking windows and doors, gaps in interior trim and floors.

Question 2: Isn't green lumber easier to nail and less likely to split?

Answer: True. But it's also true that nails in wet wood have less holding power when the wood dries (up to 25% less).

Question 3: What are rosin-coated or cement-coated nails and why are they used?

Answer: Rosin or cement coating gives nails a tacky film that creates extra friction. Thus they will not loosen, back out, or pull out easily. They are used to create a strong nailing bond.

Question 4: Why is plywood sheathing stronger than plain boards?

Answer: Plywood has several layers, which are glued in opposing directions. Since the strength of wood is greatest in the direction of the grain, this gives great strength in at least two directions. Plain boards have only the one layer and only one direction of maximum strength.

Question 5: What other advantages does plywood have that makes it superior to regular sheathing?

Answer: Plywood is faster and easier to apply and minimizes waste. It adds strength to floors, walls, and roofs when used for sheathing. Plywood is also subject to minimum swelling and shrinking, thus eliminating twisting and distortion of framework.

Question 6: If small errors are found on the plan, can the worker contact the foreman or boss and get permission to make a correction on the spot?

Answer: Yes, small errors can be corrected with proper approval.

Question 7: Can you change specifications or make substitutions without permission?

Answer: No, specifications cannot be changed at will without breaking the contract. Changes must be in writing and approved by the owner.

Question 8: Why is platform or western construction so popular?

Answer: Because it is stronger, faster to erect, cheaper, safer, and more fire resistant. It also permits a more even and uniform settling and shrinkage.

Question 9: Why is framing spaced 16″ on center?

Answer: By numerous structural tests, 16″ centers have proven to furnish safe and economical spacing for framing. Further, the 16″ spacing permits the use of standard widths and lengths of sheathing materials and siding.

Question 10: Why is diagonal bridging installed between floor joists?

Answer: Diagonal bridging acts as a load distributor. Rather than one joist's taking the full load, bridging permits an equal distribution of the load to adjoining floor joists.

Question 11: Why is wood used so widely in construction?

Answer: Wood is plentiful, relatively inexpensive, easily worked, and has great strength, durability, and beauty.

Question 12: What's the difference between air-dried and kiln-dried lumber?

Answer: Kiln-dried lumber is oven-controlled drying. It is faster and more accurately controlled than air-drying. Air-drying takes longer and involves more handling and storage space.

Question 13: Can lumber dried by air or ovens take on additional moisture from the time it leaves the mill until the time it is used?

Answer: Yes, wood is cellular and hence very spongelike. It can absorb moisture in shipment, either from rain or from moisture in the air. Hence lumber should always be protected from the weather.

Question 14: Why is Douglas-fir framing lumber rated high as framing lumber?

Answer: Douglas fir is fairly light, extremely durable, and strong. In proportion to its weight, it is the strongest wood.

Question 15: Is Douglas fir used for anything besides framing in the construction industry?

Answer: Yes, it is very versatile and can be used for window and door frames, doors, flooring, steps, the manufacture of ladders, and many other uses.

Question 16: Is common lumber used for framing graded?

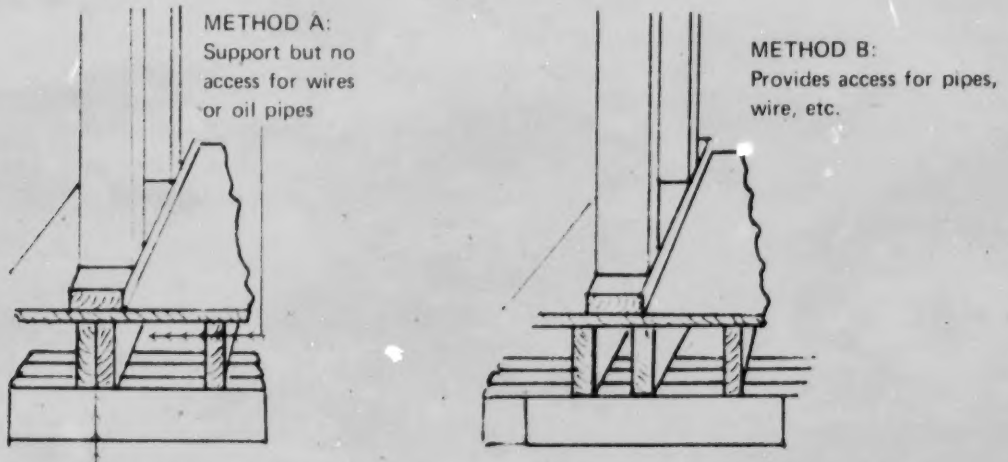
Answer: Yes, common lumber is graded from one through five. No. 1 and No. 2 common are frequently used for framing. No. 3 and lesser grades have serious structural defects and are only used for component parts or very rough work.

Question 17: Why should a sill be leveled with a bed of cement? Why not use wood shims?

Answer: Cement is firm and stable and should last the life of the building without deteriorating. Wood can be compressed or rot, which would cause cracks and other structural flaws in time.

Question 18: Why should floor joists be doubled under all partitions that run parallel with the joists, and also be doubled at all openings?

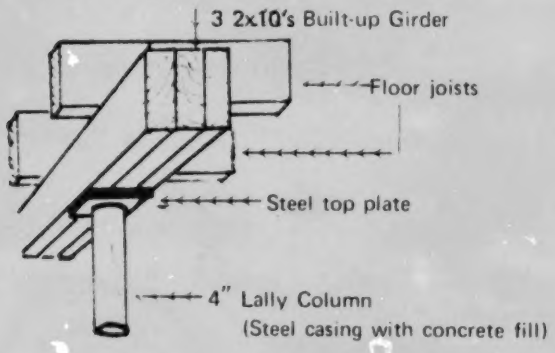
Answer: These points offer critical areas of stress by an imposed load or by omission for openings, hence the joists should be doubled.


METHOD A:
Support but no access for wires or oil pipes
METHOD B:
Provides access for pipes, wire, etc.
Double joists under parallel partitions add additional strength

DOUBLE JOISTS

Question 19: What's the purpose of a girder?

Answer: A girder takes the place of a wall to help support the floor joists and the imposed weight of the structure.



How a built up girder supports the floor joists

Question 20: Why is a girder so important?

Answer: A girder usually carries twice as much weight as a foundation wall. It carries about 50% of the total building weight.

Question 21: Why are headers used for framing over all doors and windows?

Answer: They compensate for the omitted studs by distributing and supporting the imposed load.

Question 22: Why are studs doubled at all openings?

Answer: Again as compensation for the omitted studs – adding to the structural strength by supporting the headers.

Question 23: Why is the top plate doubled on walls?

Answer: A double plate strengthens and stiffens the walls and acts as a tie in corners and junctures.

Question 24: What is the difference between a bearing and a non-bearing partition?

Answer: A bearing partition carries the weight of floor joists plus any structural weight above it. A non-bearing partition carries only its own weight.

Question 25: Explain where compression and tension take place in a framing member.

Answer: Compression is the force acting on the top edge, whereas tension is the force on the bottom edge.

Question 26: In cutting floor joists for pipes, etc., is there a safe cutting area?

Answer: Yes. There is a neutral point between compression and tension where neither force is too great.

Question 27: What is the maximum size of hole permitted in a floor joist?

Answer: A hole equal to one-fourth the total timber width can be cut in the neutral zone without creating structural damage. Any hole cut larger will require supporting framework.

Question 28: Suppose you cut a notch 4" deep in a floor joist to get some necessary plumbing in – what could happen?

Answer: The floor joist would no longer be a 2x8, for example, but a 2x8 minus 4" or a 2x4. The beam may sag unless you compensate in the framing.

Question 29: Suppose you have to cut through a bearing partition?

Answer: If you do you must compensate by steel mending plates or additional framing.

Question 30: Are there scientific principles that you must follow in every phase of framing?

Answer: No, many framing problems can be solved by common sense and experience. However, knowledge of scientific principles provides safety and security in many instances.

UNIT V – FRAME CONSTRUCTION

Sheathing Materials **Lesson 12**

Objectives:

1. At the end of this lesson the student will know the purposes of sheathing.

2. The student will also learn about the various types of sheathing and their qualities.

Related Information:

"Sheathing" refers to the external covering that is nailed to the exterior framing. It provides bracing strength, insulation, and sound absorption, and acts as a base for finish sidings.

Good sheathing should have the ability to hold nails, so that the finishing materials can be firmly held on. Sheathing should also supply a good degree of bracing ability, because modern methods of framing require it. Finally, sheathing should provide good insulation and be able to keep out wind, dust, and weather.

Sheathing materials can be in the form of boards, plywood, or a variety of composition materials. Wood sheathing is the strongest and most popular, and so let's consider the qualities of wood sheathing first.

Plain boards free of major defects can be used for sheathing but must be at least ¾" thick and should not exceed 12" in width. To supply rigidity and bracing, board sheathing should be applied diagonally, and joints should occur over studs.

Plywood sheathing comes in large sheets and is easy and fast to apply. One of the main advantages of plywood is that it has good strength either with or across the grain. Plywood consists of layers in which the grain runs in two directions at right angles. The glueing of opposing layers of wood grain actually prevents swelling and shrinkage. These advantages give plywood a rigid quality for bracing, plus a greater impact-resistance to blows or damage. The glued layers provide excellent nail-holding qualities, and nails can be used close to the edge without splitting the plywood. Plywood can also be cut and drilled with no appreciable loss of strength.

Composition sheathing, commonly known as building boards, may be made of several different types of material.

Sheathing boards are manufactured from wood, sugar cane, or asbestos fibers. Sheathing made from fibers comes in two types. One type has both surfaces and edges coated with asphalt, and the other has the fibers impregnated with asphalt during manufacture. Both types are used where moisture is a factor and insulation and sound control are more desirable than rigidity.

Composition-type sheathing requires diagonal corner bracing and has limited uses. For example, it presents a nailing problem with wood or asbestos shingles – the nailing of the siding must occur over the studs.

Research Project: See how many other composition materials are used for exterior sheathing. List them and give the advantages of each type.

Roof Framing **Lesson 13**

Objectives:

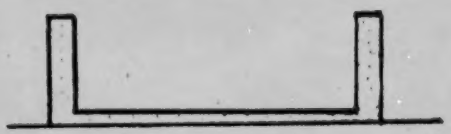
1. At the end of this lesson the student will learn about the forces that roofs are subject to.

2. The student will also learn how geography influences roof design.

Related Information:

Part I – The Almost-True History of the Beginning of Roofs

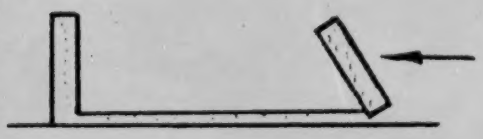
The first man-made roof was probably an animal-pelt hat, which was supported by his ears. The first hat effectively kept the dust, rocks, rain, and snow off man's bald head and kept the sun out of his eyes. This sure protected the top of the head and the eyes, but gave no protection to the nose and teeth, which were burned and cracked by the sun. And so man widened the overhang to protect his gums, teeth, and nose and started wearing the big-brim job. That's right, the big brimmed hat and the early beginnings of roof framing started in Texas – where else?



Without a roof, a structure is not complete

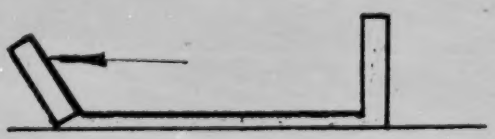
PART II – THE REALLY TRUE STORY

The first man-made roof was probably a lean-to roof supported by poles somewhere in New Jersey.

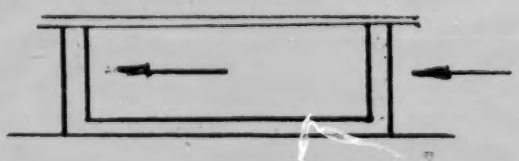


Walls alone cannot resist outside forces

As building became larger and more complicated, the same became true of roofs. Thatched roofs and tree branches were now not enough to keep out the rain, snow, and sun.



Walls alone cannot resist forces from inside



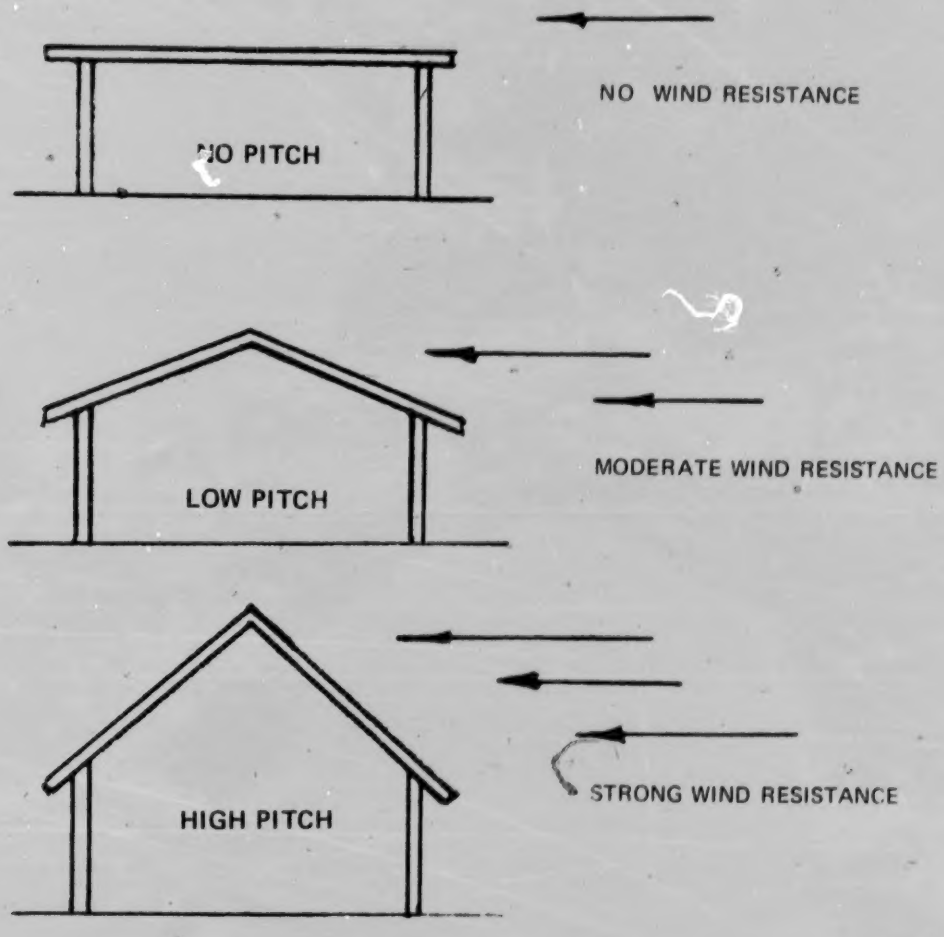
With roof on, walls can resist forces better

Thus as the size of roofs increased, the size and types of roof framing had to change to cover the span and support the load. The size of overhangs was increased also, to give more shade, and so started a whole new ball game.

Most buildings must have their walls firmly attached to both a ground support and a roof to be structurally sound. Hard to believe, but it's true. The walls of a building cannot resist the external and internal forces placed on them without some horizontal support at the top of the walls.

Roof framing in turn must be properly supported by the exterior walls. In the case of large spans, the framing must rest on load-bearing partitions plus the outer walls. Thus walls need roof-framing, and roof-framing needs walls. To keep from forgetting this, remember it's just like romance – boys need girls and girls need boys.

Roof-framing must carry two important weight loads and hence it must be structurally sound. The first load is referred to as a dead load; it consists of the weight of shingles, sheathing, and rafters.



The second type of load is the live load: it consists of the wind and snow loads that act upon the roof. Snow loads bear straight down and produce a force in a vertical position. Wind loads are forces in a horizontal direction. Hence roof pitches must consider the live loads present in a particular geographic area. For example, homes in New England need high-pitched roofs to withstand the heavy snow loads. Homes in Florida need very low pitched roofs or flat roofs to keep wind loads at a minimum.

Thus the selection of framing materials, sheathing, roofing materials, and the pitch must apply construction science or face possible failure and waste of money.

Students in past classes who fell asleep had the roofs blown off their houses – so stay awake and keep your roof on.

Roof Covering Materials **Lesson 14**

Objectives:

At the end of this lesson the student will know the most common types of roofing, and where they are used, and their advantages.

Related Information:

The exposed outer roof covering protects the building from wind, rain, snow, and cold. In the summer it keeps the heat out and in the winter keeps the heat in. Many materials are used to cover pitched roofs, such as asphalt shingles, wood shingles, and asbestos shingles. Heavily framed roofs can be covered with slate or tile. Flat or low-pitched roofs can use roll roofing, sheets of metal, glass, plastic, or any combination of these materials.

Sloping roofs are most generally covered with some type of shingle. Roof shingles are commonly made of asphalt or wood. The wood sheathing is usually covered with overlapping layers of tar-impregnated paper, frequently called "tar paper" or "felt." The shingles are then applied so that they overlap at least one-half their depth. The shingles are nailed with galvanized or non-rusting nails that are covered by the succeeding overlapping shingle. Thus nails are not exposed to deterioration, which might cause leaks.

The modern-day asphalt strip shingles are usually interlocking or have self-sealing edges. The self-sealing shingles seal their exposed portion to the shingle below, thus forming a sort of one-piece roof. This sealing feature keeps rain and snow from getting under the exposed tabs.

Asphalt shingles are made from rag felt that is saturated with asphalt, and the finish surface is covered with ceramic-coated mineral granules that are pressed into the hot surface. The tiny granules provide a fire-resistant surface.

Wood shingles, usually made from western red cedar, are an expensive but popular roofing material. Cedar shingles have a fine, even grain usually quite free of distortions, knots, or blemishes. The expansion and contraction of cedar shingles is so low that moisture conditions do not present a problem. They are extremely light, relatively free from cracking, and because of their cellular nature are an excellent insulator.

Flashing can consist of a waterproof fabric or a rust-resistant sheet metal. In most cases flashing consists of aluminum, copper, or galvanized metal and is used where different surfaces of the roof intersect. The most common areas needing flashing are the ridge, valley, hip, or chimney junctures of a roof.

The actual method of installing flashing is best left for shop instruction; however, like most roofing materials, it should be lapped at the joints.

Finished Exterior Wood Sidings **Lesson 15**

Objective:

At the end of this lesson the student will have a general knowledge of some of the many types of siding available and their characteristics.

Related Information:

Finished siding adds good appearance to a house just as clothes add to the appearance of people. But sidings, like clothes, must do more than just add beauty. Let's make a quick checklist we can use as a guide to the qualities that a siding should have.

1. Siding should be able to hold paint or other finish.
2. Siding should be reasonably resistant to weather, normal wear, and abrasion.
3. Siding should add a good insulating factor.
4. Maintenance costs should be low or reasonable.
5. Siding should be reasonably permanent, because replacement can be expensive.
6. Siding should be free of blemishes and defects such as splitting, knots, checking, or distortion.

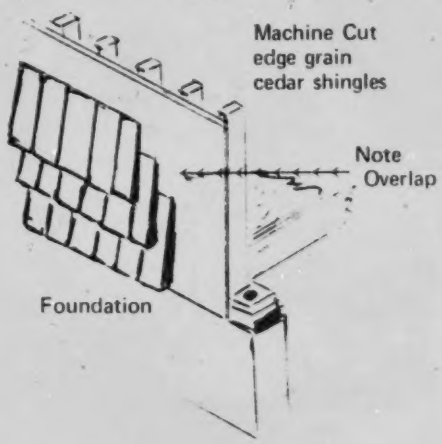
Let's take a look at the principal types of wood sidings.

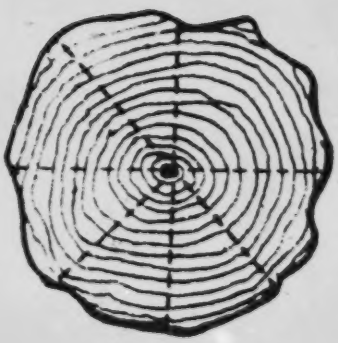
1. **Horizontal-type siding.** Several species of wood are used to make horizontal siding, but redwood and cedar are the most common. Both redwood and cedar come in a variety of shapes and sizes.
   Redwood is an extremely durable wood that can take a paint or stain finish well. It is highly resistant to moisture and decay and has a good insulating value.
   Cedar siding is made from western red cedar and has the least shrinkage of any softwood on the market. Because cedar is such a stable wood its size and joints are not greatly affected by humidity, and its great stability keeps it relatively free from cupping, twisting, or pulling loose from nails. Cedar has one of the highest insulating values of all the soft woods and can take paint, stain, or varnish exceptionally well.

2. **Vertical Siding.** Board-and-batten sidings are usually made of cedar, redwood, fir, or cypress. They come rough-sawed or smooth and are applied to the walls vertically. Then narrow strips of the same material are nailed over the vertical joints. A variation of vertical siding uses boards with a tongue and groove, with V-joint grooving.
All species of cedar and redwood can be painted, stained, or varnished and hold up extremely well. Fir siding, however, is a harder species and is more subject to checks, splits, and small defects. Cedar and redwood have the highest insulation rating, followed by cypress and fir in that order.

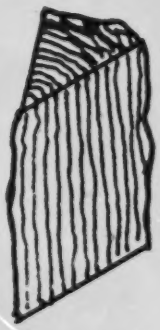
3. **Wood shingles.** Wood shingles are made from pine, redwood, and red cedar. Red cedar leads the list in quality and sales. Red cedar is a fine, evenly grained wood with a uniform texture that can't be beat. Cedar has a cellular structure that makes it extremely light, and yet it possesses unusually high crushing strength. The expansion and contraction of red cedar is minimal, and thus it can change from wet to dry with very little splitting, checking, or shrinking.
Red cedar shingles, properly installed, will normally outlast the life of the building. As a matter of fact they weather so well that they can go without paint, stain, oil, or varnish and still hold up!
Thus for beauty, durability, insulation, and maintenance, cedar shingles represent one of the best choices.

Red cedar shingles are made in several grades, depending on the degree of perfection. For example, No. 1 grade shingles are all edge-grained, absolutely clear from butt to tip, and contain no sapwood.



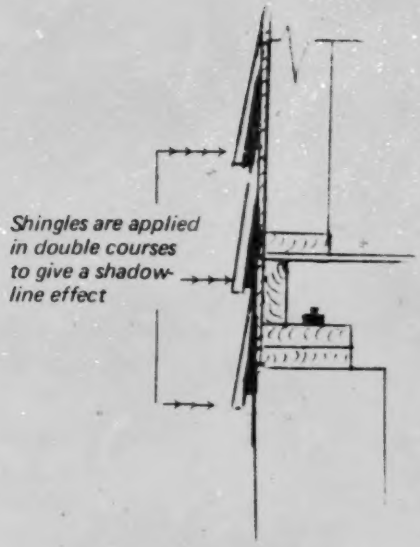


Quartered, split, and requartered until they get to proper size



Cut up shingle block

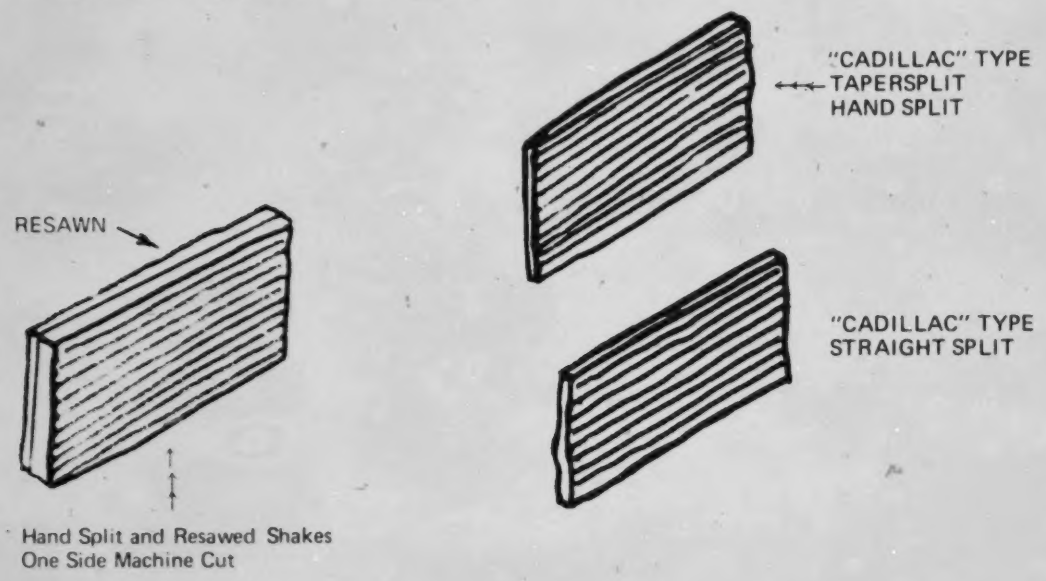
Finished machine-cut # 1 grade shingle or shake



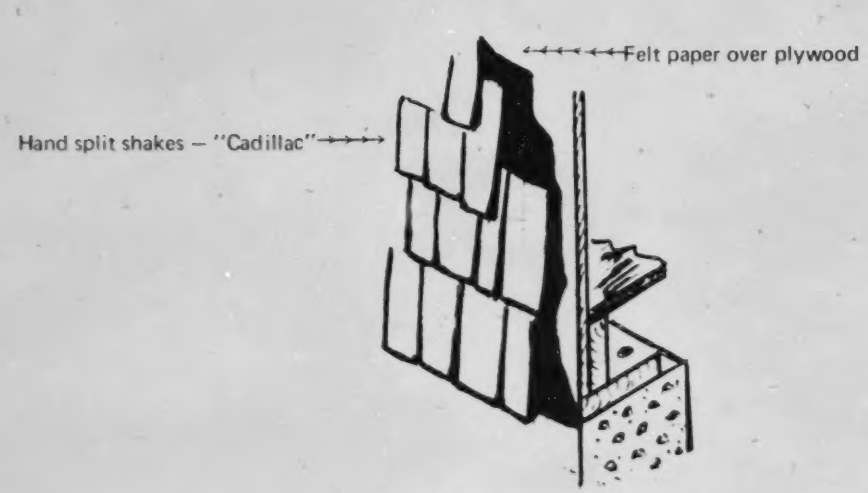
Shingles are applied in double courses to give a shadow-line effect

Red cedar shingles also come in a variety of shapes that differ in application. For example, a machined wood shake (shingle) is made that comes machine-sanded or grooved. This shake is prime-painted or stained and is even applied in a different manner from an ordinary shingle. This shake is a cheaper shingle with poor grain structure, knots, or blemishes and is used as an undercoating. The finished shake is then applied with a wide exposure, creating a shadow-line effect, and is face-nailed with galvanized nails. Conventional shingles use a concealed nailing method.

There is finally a "Cadillac type" shake that may be (1) hand-split and resawed, or (2) straight-split, or (3) taper split. They have a rustic beauty but are very expensive. These shakes are clear and are made from 100% heartwood and must be literally perfect. The selection of only the finest heartwood sections of red cedar plus the additional labor to manufacture this type are what makes them so expensive. However, they are used for siding and roofing with excellent results.



Hand split shakes give a rustic, rugged appearance



Other Finished Exterior Sidings **Lesson 16**

Objective:

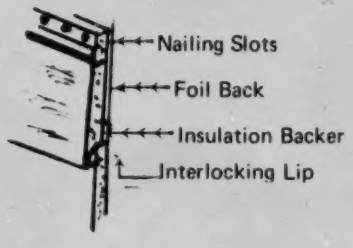
At the end of this lesson the student will know about several types of siding other than wood.

Related Information:

New siding materials are constantly being developed and used. They compete with each other in attractiveness, durability, application, and cost. It would be difficult to select one type and say it's the best. Therefore we will only list the types available without trying to make a comparison.

1. **Aluminum siding** is formed from aluminum sheets and is available in various thicknesses, patterns, textures, and colors. This comes either in single-thickness metal or with a rigid-type insulation backer such as Styrofoam. There is vertical as well as horizontal siding. It is made in various widths and usually in 12′ lengths. Aluminum siding is sensitive to temperature changes; thus nailing should be through slotted holes and at only moderate distances because of expansion and contraction. Price is usually based on thickness, which runs from 0.02″ to 0.025″. Aluminum siding's best feature is the durability of its finish. Thus appearance and minimum maintenance are its strongest selling points.

ALUMINUM SIDING



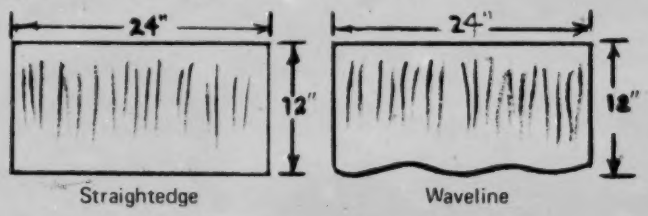
2. **Steel siding** is similar in appearance and application to aluminum. Consisting of a rust-resistant alloy, it is stronger than aluminum.

3. **Vinyl siding** is also similar to aluminum siding in appearance and application. Although durable and good looking, it presents more problems in application. It is sensitive to temperature changes.

4. **Insulating fiberboard siding** is made of a ½″ fiberboard base. The finish face is covered with asphalt and has finely crushed slate imbedded. It is made in patterns to imitate brick, stone, and wood grain.

5. **Composition board.** This type of siding is manufactured from wood fibers and wood chips and is formed into boards and panels resembling wood. It may be applied as lap siding, board and batten, or vertical siding. It comes prefinished and can be applied with nails or adhesive. Available in textured or in hard-board form, its advantages include freedom from splitting, checking, and cupping.

6. **Asbestos-cement siding and shingles.** Asbestos siding boards are made in horizontal strips, 12″ wide, 48″ long, and 3/16″ thick. They have a smooth surface and straight edge and are applied with soft-head, rust-resistant nails.



ASBESTOS SHINGLE

Asbestos shingles are 12x24 inches and are available in straight or wavy exposed edge. They usually have a wood-grained pattern and are available in a variety of colors. Application is through pre-punched holes, and asphalt strips are provided for weatherproofing the joints. Asbestos shingles are very moisture-resistant when first installed, but as they get older they have a tendency to fade and get porous. Despite the manufacturers' claims, they do have to be painted or treated when they get old and porous. Newer types of asbestos shingles have an improved glazing.

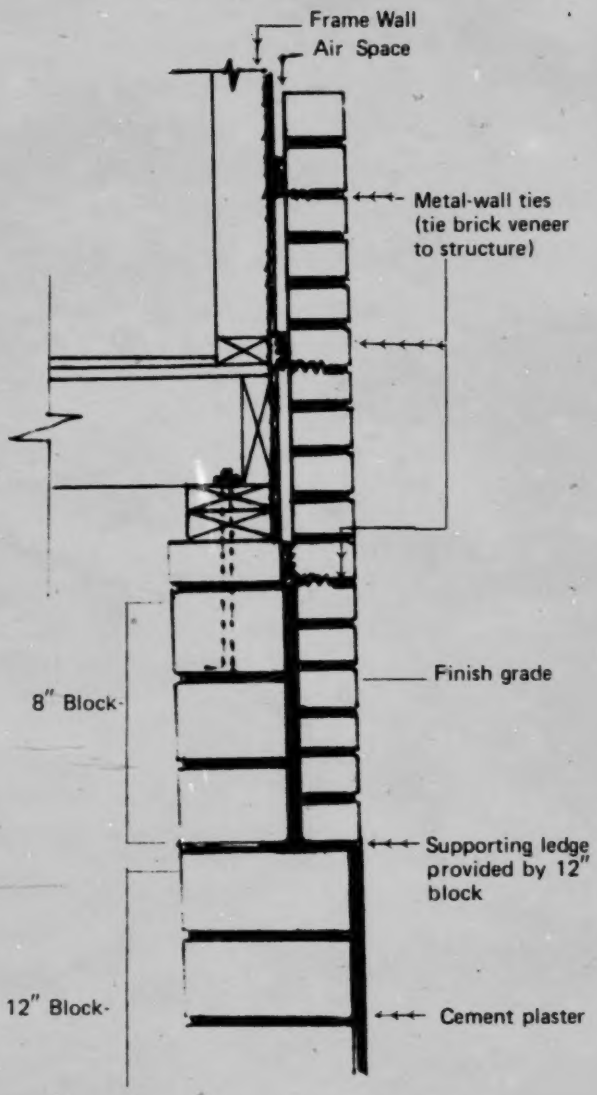
7. **Brick veneer** means a brick facing that forms an exterior finish over either wood framing or masonry construction. There are two types of brick veneer that are used over light frame construction.
(1) The first method uses brick having a 4″ thickness, which are laid up over the wood sheathing. This method requires a firm base and hence must start either on a supporting ledge in the foundation masonry or at the footing base.

The supporting-ledge construction is more common (see illustrations.) The foundation masonry consists of wider blocks below grade (usually 12″) with narrower courses of block (8″) starting just below the finish grade. This forms a solid 4″ ledge for firm support.

The brick thus furnishes a finished brick exterior over a wood-frame base, combining economy and beauty. The brick is kept about 1" away from the wood sheathing to provide an air space. This air space is vitally important because it acts as both an insulator and moisture-control feature. The air prevents the transmission of heat and cold by conduction (See Unit VII). There is some circulation of air; this prevents the moisture and humidity problems that affect insulation in situations where the air does not circulate.

The brick veneer is anchored to the wood frame by metal wall ties that are nailed to the studs and bent into the brick wall as it is being laid up. The metal ties appear at least in every fifth course and are spaced about every four feet. However, wall ties can vary with building codes or specifications.

(2) The other method is to cover the studs with paper-backed wire mesh. Thus the bricks are applied to wet mortar, just like wallpaper. However, this type is used mostly in California, and so who cares. Folks in the East do their own thing.



BRICK VENEER
OVER FRAME CONSTRUCTION

UNIT VI – PLUMBING

The Need for Health Codes **Lesson 1**

Objectives:

At the end of this lesson the student will understand why health codes for plumbing are necessary.

Related Information:

In the good old days when saloons, schools, houses, and caves were spaced far apart, folks didn't have much need for health codes. Your 10-acre spread of weeds, poison ivy, and gopher holes was your own, and your "paw" was the law.

Then saloons, schools, and houses started to move closer together – creating a need for health codes. Now, garbage thrown out the window was hitting a neighbor's house, and folks needed laws and codes to protect the citizens from each other's waste products.

This togetherness or close living was creating serious health problems with regard to drinking water and sewage disposal. So the "old fuzz," or city fathers, became concerned about pollution and the environment.

They formed a government and, in their haste, named it "Us." They slapped together some health codes and hired three unemployed colonial hippies named Washington, Lincoln, and Paul Revere to enforce them. That's exactly how health codes got started!

Thus, any student can plainly see that protection of the health, safety, and lives of people is a government obligation and rightly so. The supply of drinking water and the safe disposal of sewage vitally affect public health and hence must be regulated. Therefore plumbing systems cannot be installed in any old way, but must conform to established health and safety standards. Most communities have established health codes, and the kinfolk of Washington, Lincoln, and Revere are still enforcing them.

The enforcement of these health codes is controlled by a system that requires permits and inspections. The permits are issued and approved on the basis of plans and specifications submitted. The work is inspected while in progress and on completion. Usually a rough plumbing inspection is required before the walls are enclosed. This is to insure that all piping is properly sized, fitted, vented, and tested for leaks. An inspection is required for sewer or septic systems and their tie-in connections. Septic tanks and sewer-line excavations must be left uncovered until inspected and approved. The inspections are usually made by a licensed master plumber who is employed as a plumbing inspector, or by a sanitary engineer.

Unfortunately, codes vary from community to community at present; there is a real need for standardization of health codes. State regulations go part of the way in establishing uniformity but are limited to their boundaries. There is presently, however, a cooperative effort of state and Federal governments, manufacturers, engineers, and architects to standardize plumbing codes.

In rural areas where local plumbing codes are not strictly enforced, the property owners should comply with state codes. Information on the installation of a safe water supply and sewage disposal is available from the Federal government. Thus even the most remote areas have access to information on health codes and safe installations.

UNIT VI – PLUMBING

Basic Purposes of Plumbing **Lesson 2**

Objective:

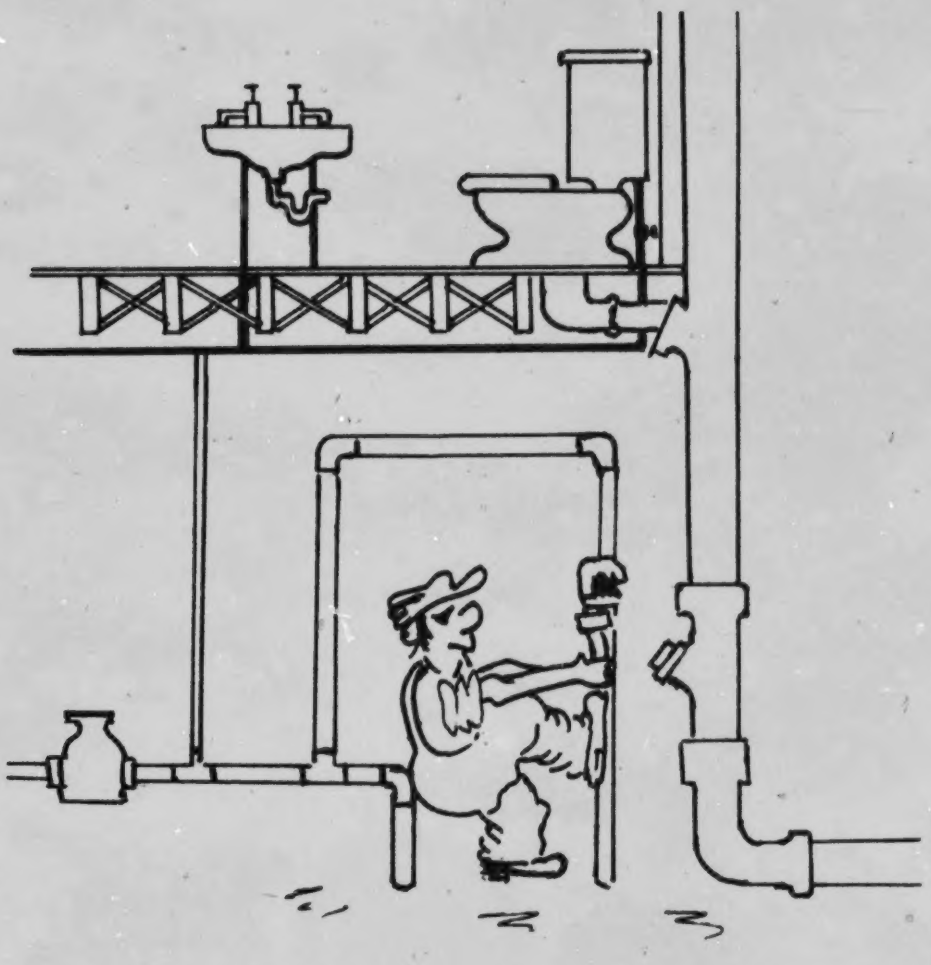
At the end of this lesson the student will know the two basic purposes of a plumbing system.

Related Information:

Americans are responsible for the highly developed system of modern plumbing. Modern plumbing is available to practically every home in America, a convenience and luxury unequaled in any other country in the world.

Imagine the feeling of security we Americans enjoy. We don't have to worry about firecrackers in the outhouse or frogs and snakes in ye olde well. We really don't appreciate our dependence on plumbing until the sewer backs up or the water supply is threatened by pollution.

Plumbing actually refers to a double system. One system supplies and distributes water under pressure for drinking, cooking, bathing, cleaning, and other uses. The distribution of water under pressure to the various fixtures in the home permits a high degree of personal hygiene.



The second system of plumbing furnishes a safe and efficient means of disposing of waste water, solid wastes, and sewer gas. This second function of a plumbing system is just as important as supplying water – if not of greater importance. The drainage system carries off bacteria-laden kitchen wastes, cosmetic and household chemicals, and both internal and external body wastes. External body wastes include hair, sputum, sweat, body oils, and just plain dirt.

The American public has a strange sense of values. For example, ask any American who developed the hydrogen bomb, and everybody knows it was Dick Tracy and the Lone Ranger. Yet who has ever used a hydrogen bomb except for a few college radicals or a handful of mean grammar school kids?

Yet ask anyone who invented the toilet, and nobody knows – not even teachers. They know it's called a john, but John *WHO?*

Distribution of Water in the House **Lesson 3**

Objective:

At the end of this lesson the student will know about three important factors that affect the efficiency of a water system.

Related Information:

The adequate supply of water and its distribution used to depend on two rotten kids called Jack and Jill. These two spoiled kids would go up the hill to fetch a pail of water and the whole town had to wait until they came back.

Jack and Jill

Jack and Jill would run around the hill for hours, throwing rocks, frogs, and coke bottles into the old well. They would finally charge down the hill with half a pail of water. This was not exactly adequate – no way! Obviously there was need for a change. Thus the thirsty, dirty, and irate citizens schemed out a better way, and this led to the first practical system for the distribution of water within a house.

The adequate supply of water at the fixtures now depends on pressure. Water pressure in turn depends on three important factors, as follows: (1) size and distribution of pipes; (2) friction; (3) obstructions.

The proper sizing of pipe for the main line and the fixtures will insure an adequate flow of water and pressure at the fixtures. Improper sizing will cause a pressure drop and in turn a poor system. Generally the main line for a small house should not be less than a ¾" pipe.

No Water Pressure

To maintain pressure and proper distribution, the domestic supply system is divided into two units: (1) the basement supply lines; (2) the fixture supply risers. The main line usually extends full size under and parallel to the floor joists to the hot water storage tank. Then from the water heater it should branch into two supply lines, one for cold water and another for hot water. These two supply lines then branch out with fixture risers of cold and hot water connected to the fixtures above. Branch lines for individual fixtures are generally ½" pipe, and for very short runs such as a lavatory or toilet a 3/8" pipe is sufficient. This graduation of pipe sizes insures adequate pressure in the system.

Friction developed in the piping system creates a resistance that can also seriously affect the pressure. Friction is produced by the contact of flowing water with the interior surface of the pipe. This water friction is further increased by the resistance between the water molecules themselves. The only practical way by which friction can be overcome is by pressure.

One practical way of maintaining pressure is by keeping friction to a minimum. Every sharp turn, pipe fitting, and stop added to the system creates resistance and results in a greater pressure loss. Thus adequate pipe sizing, as straight and direct as possible, and only the necessary fittings, insure a good working system.

Another factor that affects the efficiency of a water system is hard water. Mineral deposits from hard water build up inside the pipes and reduce the pressure. Wherever possible water should be tested and a water softener installed to eliminate hard water. Other factors affecting pressure are extremely long runs, and just too many fixtures on the line.

UNIT VI – PLUMBING

The Establishment Strikes Again **Free Information 4**

Objective:

At the end of this story the student will realize that a huge conspiracy exists to stomp on kids and their rights.

Once upon a time, a long-suffering plumber-type teacher was comparing water distribution to education when he discovered a tremendous similarity. This fine old geezer, after many years of in-depth study, reasoned that the flow of knowledge was dependent upon pressure. His theory, stated formally, was that *the flow of knowledge into the noodles of students is proportional to the pressure applied.* He further reasoned that the pressure had to be applied by parents, teachers, and kinfolk. Further investigation showed that the flow of knowledge was greatly restricted by mischief, sleeping and day dreaming in class, and playing hooky.

Every mean person in the world agreed that these sources of friction restricted the flow of education. But parents and other dedicated enemies of students such as teachers could not agree on how to reduce the friction or increase the pressure.

Finally, after many disagreements about the methods available, they got into a big fist fight. The violence was something fierce. The police finally had to come on the scene and wow, were they confused. They didn't know how to cool it. It wasn't a race riot, a strike, vandalism, armed robbery, or playing on the park grass. They finally decided to call it adult delinquency, and they forced this weary mob into compulsory mediation. And this is how the first PTA was formed.

Some of the most popular recommendations after the first meeting were shipping sticks, police dogs, electrical shock sticks, and having retired teachers patrol the class aisles. Unfortunately, when these things were tried, they did not appreciably increase the flow of knowledge in the students' noodles.

Could it be that the whole theory was wrong to start with? That this fine old teacher was barking up the wrong pipe? What do you think?

As a concerned person, what would *you* recommend to reduce mischief, sleeping and day dreaming, and hooky? Remember that someone, somewhere, in a moment of weakness once said, "Even students have rights."

Right on.

UNIT VI – PLUMBING

The Drainage System **Lesson 5**

Objectives:

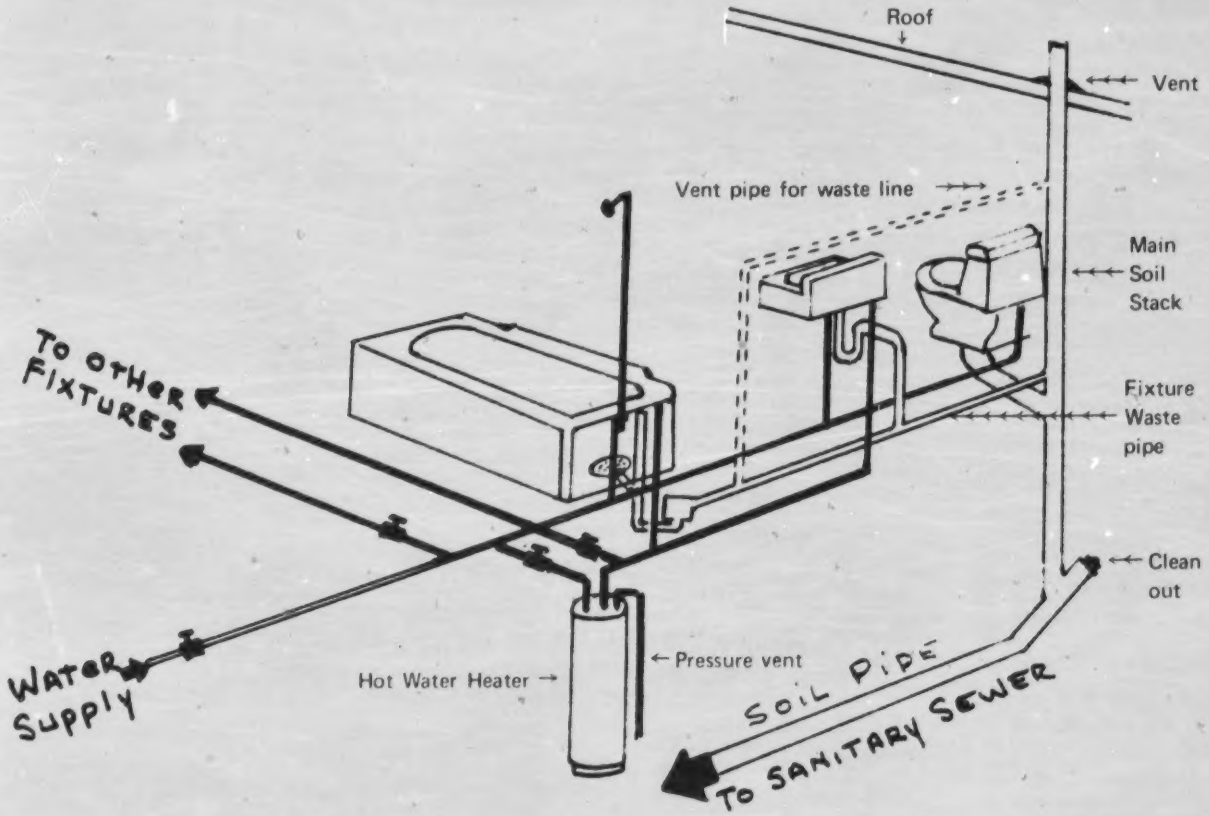
1. At the end of this lesson the student will know what the two basic parts of a drainage system are.

2. The student will also know what other parts a drainage system includes.

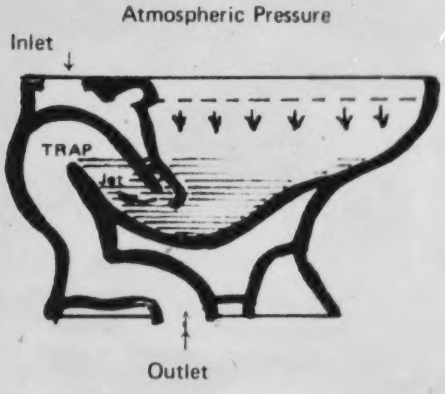
Related Information:

The two basic parts of a drainage system are the house drains and the soil stack. These two main parts consist of (1) a network of pipes that carry off the liquid and solid wastes and (2) other pipes that ventilate the system.

Those pipes carrying liquid wastes from sinks, lavatories, and bathtubs are called **waste pipes.** The pipes that carry toilet wastes are called **soil pipes.** Both sets of pipes empty their contents into the large, vertical, **main soil stack,** that connects to a large horizontal **house drain.** The house drain is pitched so that the wastes flow by force of gravity into the city sewer or the septic tank.

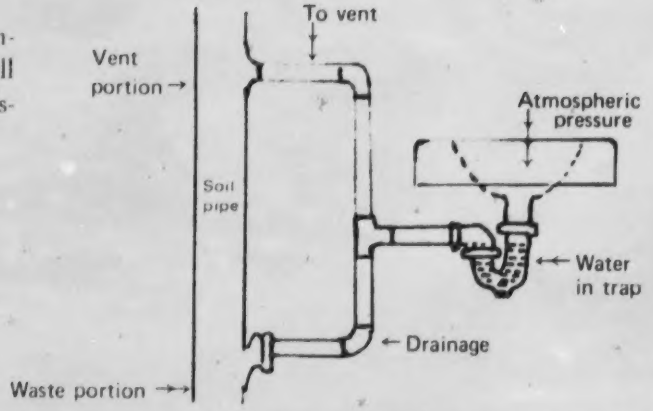


The soil stack travels vertically through the house walls and emerges through the roof. Thus the lower portion carries off the solid wastes, and the upper portion carries off the gases that form in the wastes. Every fixture must be vented to the air in some way. Vent pipes should be extended *above the highest fixture* and then connected to the main stack.

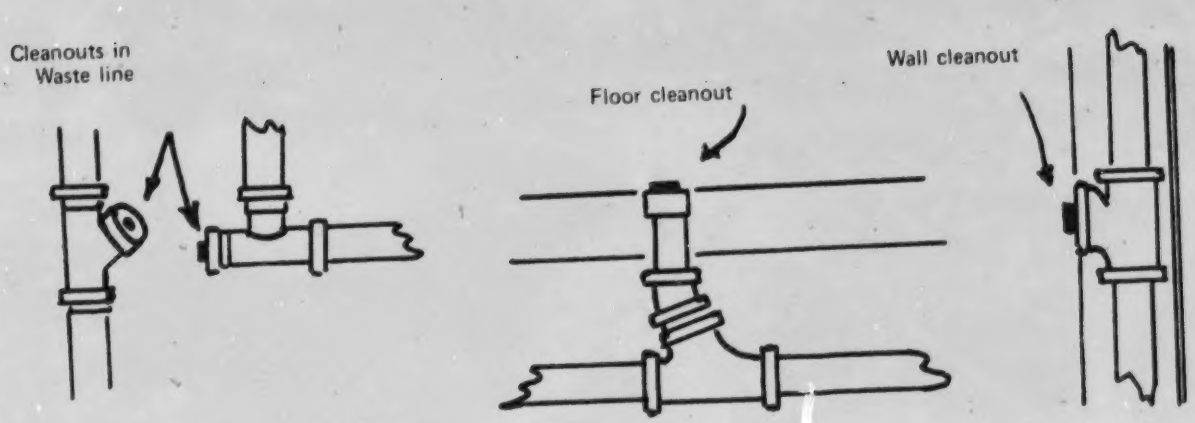


Traps are extremely important parts of a drainage system, because they prevent the sewer gas from backing into the house. Water in the trap acts as a seal to prevent a sewer-gas back-up. Atmospheric pressure helps to maintain this water level in a trap. Each plumbing fixture should be provided with a trap. Even the "john" has a built-in water trap.

The **vent pipes** are just as important as the traps, as you will see in the next lesson after we discuss ventilation in the system.



Wash basin water acts as water trap to prevent gases from backing up



Finally, the drainage system must provide cleanouts for access. Cleanouts are threaded plugs that can be removed so that grease and solid obstructions can be taken out or dislodged from the pipes. Cleanouts would not be necessary for big persons called adults, but nasty, mischievous kids vandalize the system. They throw combs, lollipop sticks, wads of gum, beer caps, and even rocks into sinks, etc. It's a case of using cleanouts or more discipline – and as usual the kids win. That's why plumbers always ask you, "How many kids you got?" before they put in the system.

"HOW MANY KIDS YA GOT?"

UNIT VI – PLUMBING

Ventilation **Lesson 6**

Objectives:

1. At the end of this lesson the student will know how ventilation can prevent three major plumbing problems.

2. The student will also understand that an understanding of the principles governing atmosphere pressure is necessary to understand plumbing.

Related Information:

Science teachers for the most part are kind, non-violent, dedicated persons that rarely loose their cool. However, science teachers have one weak spot that causes them to flare up and stomp on pieces of chalk. They insist that students respect scientific principles at all times. So don't question the value of science and its application to ventilation in plumbing. Please the teacher and keep the peace.

The purpose of ventilation is to maintain *atmospheric pressure* within the drainage system so that it will work properly. Proper ventilation prevents three major plumbing problems, namely, *retarding the flow of waste, material deterioration, and loss of seal at the traps.*

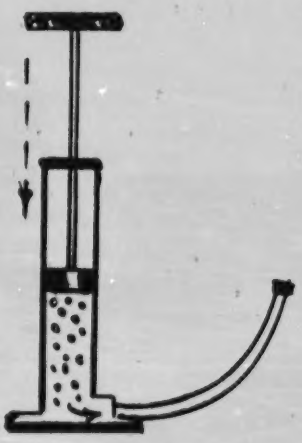
Every science student in the world knows the following facts about atmospheric pressure, but let's review them just to please the teacher.

The atmosphere is that big ocean of air that forms the outer layer of the earth. Air has weight, and so the closer this layer of air is to the earth, the greater the pressure. This ocean of air extends outward for hundreds of miles and becomes thinner and lighter as the altitude increases.

This atmosphere exerts a pressure of 14.72 pounds per square inch at sea level, under average weather conditions. This air pressure is exerted on every square inch of earth, whether liquid, solid, or gas, and in all directions – down, up, and sideways.

We are not conscious of air pressure because it is pressing on us equally in all directions. If the pressure on one side of anything is lessened or removed (as by sucking on a straw in a bottle of soda), the air pressure on the *other side* will make itself felt immediately. (It will push the soda up into your mouth.) This is the principle of the *siphon.*) If you don't believe that air has pressure, try emptying a narrow-necked bottle of catsup.

There the catsup sits, and nothing happens. You'd think it would be heavy enough to drop right out, but it doesn't. What holds it in? The pressure of the air is exerted upwards against it, and there is very little air inside to press down and push the catsup out. You can only get it to come out by giving it a good, swift kick in the rear!



Air can be compressed or it can be withdrawn. Anyone that has pumped up a bike tire knows that air can be compressed. Anyone that has squeezed an open rubber ball (as on a medicine dropper) created a partial vacuum that causes air to rush in when his hand is released. Thus air pressure can be minus or plus the 14.72 pounds per square inch that is normal. That's where science enters the plumbing picture.

In plumbing, the ideal condition is to have air pressure on the fixture side equal to the pressure on the venting side. Unequal atmospheric pressure can cause a fixture trap to siphon out the fixture's water-seal directly or indirectly. Direct siphoning is caused by unventilated traps, and indirect siphoning by the momentum of water rushing past a trap.

Thus proper ventilation is necessary in a properly working drainage system. The main soil and waste vent that extends through the roof furnishes this ventilation. The main soil vent is not only the source of air pressure in the plumbing system, but also carries away objectionable gases and odors.

Now you see several reasons why vent pipes are so important in plumbing systems (1) They prevent the water seal in traps from being sucked down, either by a siphoning action or by the momentum of the discharge flow of water; (2) They carry sewer gases away; (3) They prevent back pressure from forcing water out of the trap through the fixtures.

There are other reasons too. The wastes flowing through a plumbing system contain many elements that can combine to create acid compounds that can deteriorate pipes and fixtures. Hydrogen, which is a component of all acids, is found in large quantities in the drainage system. Hydrogen is present both in a free state and combined with other elements and should be eliminated by adequate ventilation. Otherwise it might cause a fire or even an explosion.

Furthermore, the flow of wastes can be retarded in a drainage system if atmospheric pressure is improper due to insufficient ventilation. The flow of water in an improperly ventilated soil pipe can compress the air in a soil line to be greater than atmospheric pressure. This excess pressure will retard the flow of water unless the air is permitted to escape.

It's hard to believe that ventilation is so important in a plumbing system, but that's what the teacher says. And as any student that has served detention knows, teachers are never wrong – no way.

UNIT VI – PLUMBING

Sewage Disposal **Lesson 7**

Objective:

At the end of this lesson the student will know that the conversion of raw sewage from harmful to harmless depends on bacterial action and oxygen.

Related Information:

Sewage disposal is necessary to avoid contamination of water and also the spread of disease.

The disposal of raw sewage in a municipal system requires a thorough knowledge of science, and is entrusted only to licensed sanitary engineers. The health and welfare of every citizen in the community could be affected by improper handling of sewage.

The municipal system consists of large sewer pipes, pumps, and a treatment plant. The raw sewage does not handle just human wastes but includes all kinds of materials from industries as well.

The main sewage plants use a variety of methods to treat the sewage, but the basic science is the same. The primary purpose is to convert the raw sewage by bacterial action to harmless substances. Raw sewage contains a large percentage of *anerobic* bacteria (those that do not need oxygen to live); they produce a foul odor. By introducing air or oxygen into the raw sewage, other types of bacteria, called *aerobic*, take over. The aerobic bacteria are oxygen-users and cause a rapid decay of sewage. These are the same kinds of bacteria that cause decay of all dead plant and animal matter; we couldn't live without them. The raw sewage is exposed to oxygen in open tanks or has oxygen forced through it under pressure.

The sewage is also treated by chemicals to cause coagulation and to kill harmful bacteria. Treatment also includes removing the objectional gases that form, and the huge amounts of water. When completely treated, the dried remains, or sludge, is harmless and may be used for fertilizer. However, many treatment plants do not do a complete job, and then the solids must be dumped in the ocean or elsewhere, where they may still be a hazard to man.

A *septic system* is used as a private sewer disposal where city sewers are not available. The septic systems used today come in a variety of designs, shapes, and sizes, but their primary function is to convert waste solids into harmless liquid wastes by bacterial action. The system usually consists of a steel or masonry storage tank and a dry well or drainage system to dispose of the liquids by a leaching action (Seepage into the soil).

A well-planned septic system should be installed according to the following guidelines:

1. The site should consist of sandy or gravelly soil for good drainage.

2. The unit should be planned to use the slope of the land to take advantage of gravity flow.

3. The system should stay reasonably close to the surface, because aerobic bacteria are only available to about a 5-foot depth, below which there is not enough oxygen.

4. The location should not endanger well water, streams, etc.

Two other important tips about septic systems:

1. Never dump wastes such as grease, oils, chemicals, or acids into a septic system. They are resistant to bacterial action and some may even destroy the useful bacteria that break down wastes.

2. Working in a septic tank sounds like a big joke, and yet some people must do this. This work is extremely hazardous and the workman should be cautious.

A septic tank is usually poorly aerated and there is a shortage of oxygen. The tank may contain harmful or dangerous gases that can kill. It may also contain inflammable gases, which could be ignited by a cigarette or an improperly insulated electric cord.

Young, inexperienced workers can be easily placed in a hazardous situation such as this by a careless boss or friend. If it happens to you, stay alert and remember what you have learned.

UNIT VI – PLUMBING

Water Impurities **Lesson 8**

Objectives:

1. At the end of this lesson the student will know that water in its natural state is never pure.

2. The student will also know that the primary concern of communities and public health officials is to furnish water that is safe to drink.

Related Information:

Water that we use to drink, cook with, and bathe with comes from one of two sources. It can come from the water that falls to the earth and is found in lakes, streams, ponds, and rivers. Many communities collect, store and distribute this water to their residents for domestic use.

Other communities get their water from deep artesian wells. Here again the water is collected, stored, and distributed to the homes in the community.

Thus it is easy to understand that water in its natural state is never pure. Surface water contains organic impurities, including germs from decayed plant or animal matter, plus minerals. Surface water can also contain dissolved gases, sand, clay, and manufacturing wastes.

Well water can contain minerals such as calcium, magnesium, sulphur, iron, chlorine, and dissolved gases. Back in the good old days before high schools were invented, the well was a big hole in the ground with an old wooden bucket, a rope, and a well wheel to pull it up. The open well was an open invitation to all kinds of mischief: frequently ye olde wooden bucket contained frogs, goldfish, old shoes and other goodies.

If this lesson on water turns you off and you decide to quit drinking water and taking baths, nobody will get mad. This country of ours is facing a critical water shortage and you might be considered a national hero.

The communities that supply your water and the health officials are primarily concerned with making your water supply "fit to drink." Their primary concern is to destroy harmful bacteria in the water and remove objectional odors. (This also includes removing the frogs, goldfish, old shoes, and tree stumps.) The purifying is done by filtering, aerating, and the use of chemicals.

The purified water you use, however, can still contain minerals, sand, silt, and dissolved gases. These substances may affect your cooking, bathing, cleaning, and even water pressure; however, the water is safe to drink.

UNIT VI – PLUMBING

Hard Water Vs. Soft Water **Lesson 9**

Objectives:

1. At the end of this lesson the student will know the difference between hard and soft water.

2. The student will also learn how hard water affects plumbing and cleaning.

Related Information:

"Hard" water refers to water that contains mineral deposits. The water becomes hard by dissolving minerals as it passes through the soil and rocks. Hard water does not clean too well because it does not lather with soap. It also causes the "ring" around the bathtub.

Hardness does not make water unsafe to drink, but it creates all kinds of mischief in cleaning and cooking and in heating and plumbing systems. Water can be temporarily hard or permanently hard, and so let's clear up this point first.

Temporary hard water can be "softened" by boiling. It contains some calcium and magnesium salts. Boiling changes the dissolved compounds that make water hard into others that are insoluble. The new compounds settle out as tiny solid particles, and the water itself becomes soft.

These insoluble particles cause scaling to form on the insides of cooking utensils and in water pipes. Did you ever see the hard white scaling on the inside of cooking utensils and in water pipes? Did you ever see the white coating left in a pot when all the water has boiled out? Well, if you find white coatings or scale in your pots, it's not water dandruff, brother, it's calcium carbonate.

The plumbing and heating systems can be seriously affected by this scale, because it reduces the water flow and wastes fuel. The thicker the coating becomes, the slower the water heats and the slower it flows.

Permanent hard water cannot be softened by boiling; it must be softened chemically. By adding certain chemicals, the calcium and magnesium salts are converted into other compounds that form solid particles and settle out. The two most-used water softening compounds are washing soda and borax. Practically every commercial washing powder contains one or the other or both. They combine with calcium and magnesium and settle out, leaving the water soft.

Please note that water softened by washing soda or borax, or detergents formulated with them, will soften water for washing purposes but is too harsh to be used for bathing or washing of hair. These chemicals remove oil from the skin and hair.

The most practical and economical method for softening water in the home is a zeolite water softening system. Zeolite is a mineral additive for home water softeners which provides soft water that is suitable for drinking, cooking, bathing, and washing.

Soft water is kind to plumbing and heating systems and is really necessary to maintain water pressure and to conserve fuel. Hard water is expensive when it fails to clean or clogs pipes, so teach your "maw" or "paw" a lesson if your home water supply is hard.

UNIT VI – PLUMBING

Types of Plumbing Pipes Used **Lesson 10**

Objective:

At the end of this lesson the student will know about the various types of pipes used in water-supply and drainage and vent lines.

Related Information:

Pipes are classified by how they are used in home plumbing systems. (1) Water-supply pipes can be of copper, steel, galvanized iron, brass, or plastic. (2) Drainage and vent pipes can be of cast iron, galvanized iron, copper, lead, or composition pipe such as Orangeburg, Transite, or vitrified clay.

1. **Copper pipe.** Smaller sizes of pipe are possible with copper because the inside surface is smooth and restricts the flow of water less. The smaller sizes permit easier installation in walls and through framing. Copper is extremely easy to cut and to install fittings to. Soldering eliminates threading, which saves labor and reduces the likelihood of leaks.

2. **Brass pipe.** Brass pipe resists corrosion and is preferred to iron or steel pipe. It is threaded and uses fittings similar to iron or steel but needs special cutting fluids when cutting threads. Brass pipe is bulkier and more expensive than copper and thus has limited use.

3. **Galvanized iron or steel** are used primarily for drainage and venting, but have some use as water pipe also. Both are subject to rust and deterioration and hence have a limited life as water pipes. Iron pipe, however, is used for steam pipe because it can withstand greater pressures. Galvanized iron and steel pipes are connected to fittings by threads. The threads are smeared with a pipe-threading compound called dope.

4. **Plastic.** Plastic pipe is relatively new on the plumbing scene but is rapidly being accepted for many applications. It is extremely light but strong and flexible. Plastic pipe will not rust or rot and can be cut with a hacksaw or a knife. Plastic pipe is especially adaptable for jet wells and cold water lines because it will not freeze and split.

In new-home construction it is used primarily for underground water connections for wells, irrigation, swimming pools, and exterior connections. However, it is not suitable for hot water or high heat. It can be connected with clamps much the same as rubber-hose connections in a car. Plastic can be also threaded like any other pipe, but should only be used for low pressure and gravity lines.

5. **Lead pipe** is one of the oldest materials used in plumbing and the least subject to corrosion. It was once used for water pipe and was satisfactory when used with hard water. However, soft water contains oxygen, carbon dioxide, and organic acids that attack lead, and so the water becomes unsafe to drink. The pipes also deteriorate.

   Lead pipe is still used in homes, however, in the drainage system. It has the advantage of being flexible and thus can withstand settling of the structure. Pipes are subject to vibration, expansion, and contraction that can bring on leaks, but lead is both flexible and durable.

6. **Cast iron** soil pipe is used for house drainage lines and soil or waste stack. This pipe ranges in size from 3″ to 6″ in diameter and comes in 5′ lengths for home plumbing. Some pipe is coated with coal tar to make it acid-resistant, but it also comes untreated. It can be joined by molten lead at the joints or by a neoprene compression gasket. This pipe is strong and resists rapid corrosion and breaks.

7. **Vitrified clay** has a shiny, glazed surface like ceramic tile and is unaffected by acids, alkalies, solvents, or wear. It varies in length from 2′ to 3′ and comes in a wide range of diameters. It is excellent for underground use and is easy to install. The joints are sealed with packed fiber called oakum and finished with mortar joints.

8. **Asbestos cement pipe** is a very hard, strong, and dense pipe made from asbestos fiber, cement, and sand, under great pressure. It comes in 5′ and 10′ lengths in a variety of diameters and is used primarily for drainage or waste.

9. **Bituminized fiber pipe** is a black drainage or waste pipe similar to asbestos in sizes and uses. It is frequently referred to as Orangeburg pipe, which is a trademarked brand. However, there are many similar black fiber pipes on the market today.

Inspections **Lesson 11**

Objectives:

1. At the end of this lesson the student will realize the importance of inspections in the prevention of defective workmanship and defective materials.

2. The student will know about three types of tests.

Related Information:

Once the rough plumbing of the waste, soil, and vent pipe have been completed it should be subjected to a rigorous test and inspection. This not only furnishes the home owner with a safe system but also certifies that the workmanship is proper. To close the walls in with sheetrock or plaster without a rigid test is a risk no homeowner or plumber should take. For example, the material itself could be defective, and the plumber would risk legal action despite good workmanship.

In many communities the building inspector is also the plumbing inspector, but that's truly a bad scene. A building inspector's background is usually too general to spot specific material or mechanical defects. Some communities are too small to employ a full-time inspector and usually hire a local plumbing contractor on a part-time basis. Neither system is adequate to properly protect the consumer.

Large cities often employ a full-time staff trained in sanitation and plumbing. Thus the workmanship and materials get a thorough inspection. A trained staff is in a position to keep up with current methods and materials. These people can also cooperate with professional organizations, manufacturers, and research groups on the latest developments in installation and materials.

Part-time Plumbing Inspector

There are three basic methods for testing a drainage system:

1. **Water test.** After a drainage system has been completed, the street end of the house drain and any floor drains or clean-out plugs should be closed with rubber test plugs. All other openings below the top of the stack are closed off and all waste pipes should be capped.

When all the openings are made leak-proof, the entire house drain is filled with water, usually by a hose. The pipes and joints are then inspected for leaks. Any defects must be repaired or material replaced. This system is most widely used and accepted.

2. **Air test.** This test is performed in basically the same way as the water test, but sealing must be complete. Air at about 5 pounds pressure is pumped through a test plug that has an adapter and pressure gauge. Air leaks are hard to detect, so an odor-producing additive is put in to give any possible leak a telltale odor. Some plumbers use soapsuds. When the test of a poor job is over, they can blow soap bubbles in the cellar.

3. **Smoke test.** This is an old time plumber's trick and is done basically the same way. A smoke-producing gadget forces smoke into the system with an air pump. The system is far from safe or perfect, so don't use it. But it's good to know and you can impress your college-bound friends. Better still, tell them your paw invented it.

UNIT VII – HEATING AND COOLING

Transmission of Heat **Lesson 1**

Objectives:

1. At the end of this lesson the student will understand what heat is and the three ways that heat may be transferred.

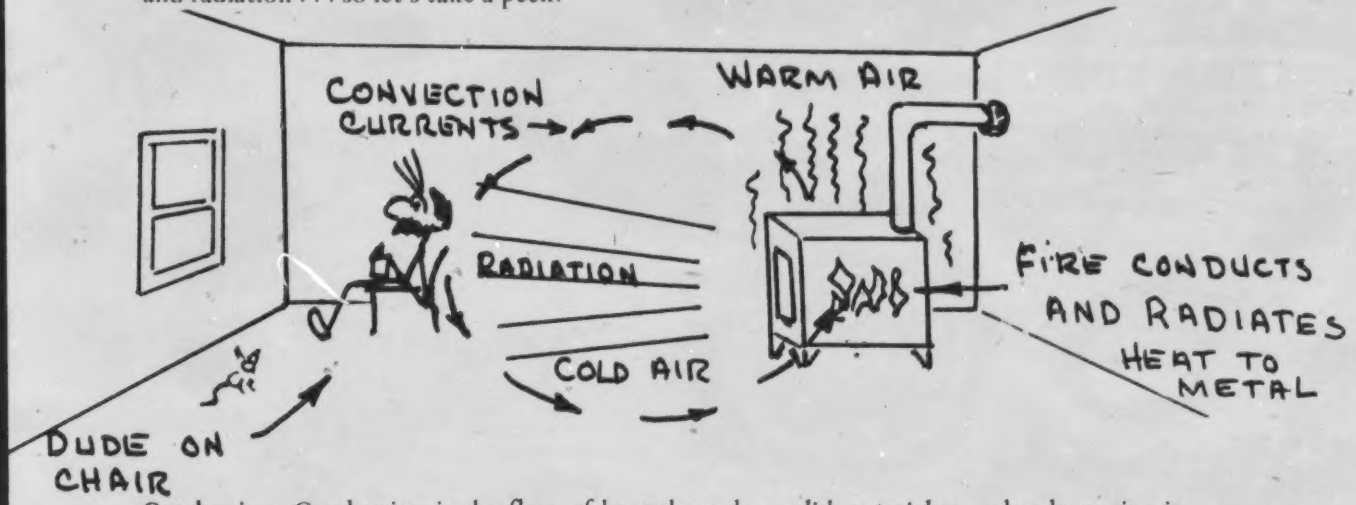
2. The student will also understand how these heating methods are applied to home heating.

Related Information:

To understand the heating and cooling of a house, you should know about transmission of heat, circulation of air, and humidity. This lesson will deal primarily with how heat is transmitted in a house.

Heat is produced by the motion of the molecules of a substance. The faster the molecules move, the hotter the substance. The hotter the substance, the faster the molecules move.

The three ways of transferring heat from one place to another are conduction, convection, and radiation . . . so let's take a peek.



Conduction: Conduction is the flow of heat through a *solid material* as molecule motion is passed along in a series of collisions. For example, if you heated one end of a length of copper pipe over a flame, it would soon get too hot to handle. The heat was *conducted* from the hot end to the cold end, which promptly heated up.

Most people would use a glove or a rag to protect their hand from the hot pipes. Did you ever wonder why certain materials slow down the passage of heat?

Well, some materials conduct the heat from molecule to molecule faster and better because of their composition (molecular structure). That's right, some molecules are packed as tight as kinfolk in a fist fight, and the heat travels rapidly from one to the other. Metals are a good example of tight molecular structure, and so they are used to transmit heat in pots, pans, furnaces, and radiators. Other materials, such as wood, plastic, and fiber, have widely spaced molecules and are poor conductors of heat. Good conductors of heat are used for heating systems, and poor conductors are used for insulation.

Convection: Convection is the transfer of heat by means of moving liquids and gases. For example, when air is heated the molecules in air get all agitated, move faster, and spread further apart. Thus the air gets lighter. Cooler, heavier air sinks down, pushing the warmer, lighter air up. This movement of heated air thus sets up *currents* of air, that is, a continuous circulation of air.

Heating a home with a hot-air system is done directly by these convection currents. Convection is also a factor in other home-heating systems, although not quite as directly. Let's look, for example, at a hot-water heating system.

Water acts the same way as air when it is heated. When water is heated, the molecules move faster and spread farther apart, and the water becomes lighter. The unheated water, being heavier, sinks, causing the heated water to rise. This sets up convection currents similar to those in air. In a hot-water heating system, as the water is heated this circulation takes place until all the water is heated. The hot water is then circulated by a pump to the radiators. The radiators in turn conduct their heat to the air next to them. Once again convection currents form and the heat is carried throughout the room.

Radiation: Unlike the two ways of heat transmission described above, radiation does not require matter (molecules) to transfer heat. Indeed the heat of the sun comes to us across 93 million miles of vacuum by radiation. If you bring your hand *near* a hot object, you will feel the heat. This too is radiation.

Radiation is energy sent out in the form of waves from any hot object. Radiation does *not* heat the air between objects, but it heats any object in a direct line with the hot object. For example, the heat from a fireplace radiates into the room and heats any objects in a direct line. But someone standing in front of the fireplace will cut off the heat from someone else standing behind him. In fact, if he is facing the fire, his own back may be cold!

Let that be a lesson to you. Don't depend on a fireplace to keep you warm. You may end up with a roasted nose and a frosted rear end.

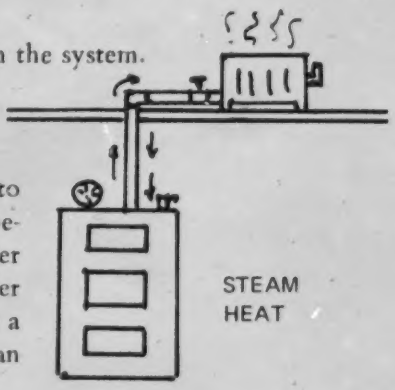
UNIT VII – HEATING AND COOLING

Methods of Heating – Steam **Lesson 2**

Objectives:

1. At the end of this lesson the student will understand why steam produces heat faster than hot air or hot water.
2. The student will also learn the purpose of the valves in the system.

Related Information:



Steam heating is one of the fastest and cheapest ways to heat a house. It is produced by heating water until it becomes a gas (water vapor or steam). The amount of water that needs to be heated is far less than that in a hot water system. In addition, this highly expanded vapor produces a powerful pressure that races through the pipes faster than hot air or hot water.

When steam reaches a radiator it transfers its heat to the radiator by conduction, cools and *condenses* back into a liquid. The change from a gaseous state to a liquid produces great quantities of heat, and then the water as it cools gives up still more heat to the radiator. The cool water flows back through the same pipe by gravity and repeats its heating cycle.

The hot radiator heats the surrounding air by conduction; this sets up convection currents which quickly heat up the whole room. Thus the air-flow near, under, and around the radiator should not be obstructed. (Like all other hot objects, radiators also give off heat by radiation – just in case you were wondering.)

Steam can produce powerful explosive pressures, and so a safety valve is installed in the top of the furnace. This safety valve is usually set to open or blow off at 15 pounds pressure. (That is, 15 pounds above normal atmospheric pressure.) Most safety valves have a small lever that can be operated manually to test the effectiveness of the valve. If the test lever will not open and release steam, or if it leaks continuously, it is defective. *Never* try to repair a valve without shutting down the furnace and cooling the system. Replace the complete valve with a new factory-set unit. *Don't* tamper with the old one – it's *never* safe.

Each radiator has an air valve that opens to release cold air in the radiator and permits the hot steam to enter. When the cold air is expelled and the steam reaches the valve, it closes again to keep the steam from escaping. When an air valve is defective, the radiator will become air-bound and prevent entry of steam. Then you have the choice of replacing the valve or shivering to warm up.

Steam has been leaving the home-heating scene just as snuff, moustache wax, derbies, and spats left the life-style scene – real swift.

The radiators are bulky, hard to clean and paint, and folks don't need them to dry out wet clothes anymore. It's really sad, because they used to be a good safe place to hide your gum and heat your frozen pizza pies on.

However, steam is still on the scene in classrooms. Students frequently heat up dedicated teachers to the boiling point and produce great quantities of steam that way. To date this form of heat has had very few practical applications, but it sure creates convection currents in the classroom. This heat is very easy to produce with any type of fuel, but hard to control. Some teachers just hiss through their teeth and others wave their arms and their eyeballs sort of pop. Avoid this type of heat like homework, because it spreads like measles to the principal and parents. That's why wise persons are always saying "cool it."

UNIT VII – HEATING AND COOLING

Methods of Heating – Warm Air **Lesson 3**

Objectives:

1. At the end of this lesson the student will understand how modern hot-air systems have been improved over former systems.

2. The student will also understand how friction affects the pressure and efficiency of a system.

Related Information:

No lessons on heat would be complete without a short history of warm-air heat. History records that warm-air heat came on the scene right after the covered wagon, but just before the Model "T" Ford.

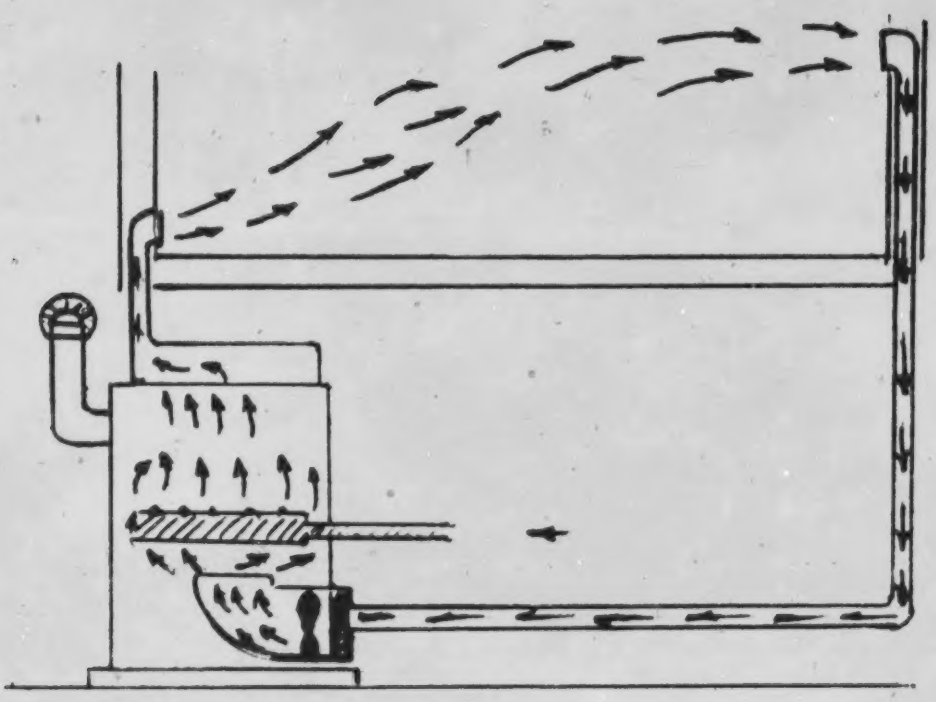
The early, gravity-type warm-air heating systems were so uneven that freezing or roasting to death were an ever-constant danger. Then the air would get so dry that folks' tongues would dry up and they'd be speechless for days. As a matter of fact, it was dryer than driving a pack of mules across Death Valley with no hat on.

Then one day a group of dedicated people got together – a science teacher, a plumbing contractor, and a saloon keeper. They decided to apply science and save the warm-air system. This science lesson is dedicated to those noble persons.

The early warm-air heating systems furnished heat that was uneven and dry. The furnace was centrally located, leading directly to the floor above, which had a floor register. The system worked only on gravity, and hence the circulation was poor.

Then later systems provided hot- and cold-air returns connected by ducts to a furnace that pushed the heat by a blower fan. This was still imperfect, as the return air grilles were placed on the outside walls. They tended to pick up mostly cold air from windows, cracks, and the cold outer walls.

Finally these three people put it all together and installed diffusing-type outlets for warm air underneath windows and along exposed walls. Now the cold air was met with warm, rising air and mixed. Thus to get the full benefits of perimeter heating, all cold surfaces should be met and covered with currents of heated air. Briefly put, counteract the cold air with warm air.



CONVECTION CURRENTS OF HOT AIR HEAT

Thus the modern warm-air system consists of warm air forced by a blower fan, with adequate hot- and cold-air ducts properly placed. It further includes an electric thermostat, humidistat, humidifier, and an electronic air filter. So, if your house resembles Death Valley, one of the above parts is missing, improperly installed, or out of order.

An important application of science is the effect of friction on air pressure. A constant friction exists between the metal ducts and the air flowing through them. This friction is further increased whenever the direction of air-flow changes. Hence elbows, angle turns, register frames, and even smooth transitional fittings increase the friction. This friction causes an appreciable loss of pressure. This is extremely important in laying out the job, selecting materials, and selecting the proper fan. The total resistance should be kept to a minimum, and the fan must be large enough to overcome the friction that exists.

Remember that in heating, plumbing, and air conditioning, the factor of friction always exists. Thus, this simple fact should guide you in making your installation as short and as straight as possible. Also; all material sizes and motor power of pumps and fans must consider friction loss.

UNIT VII – HEATING AND COOLING

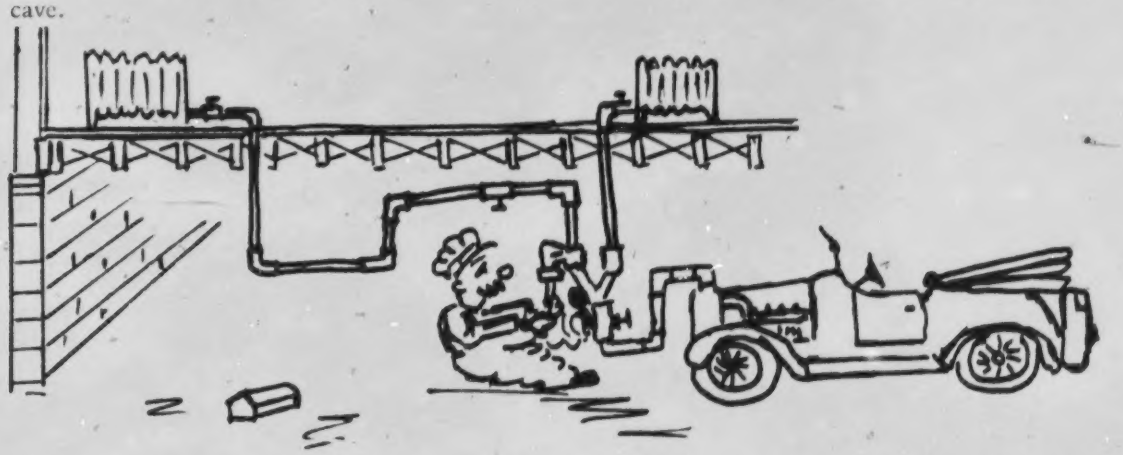
Methods of Heating – Forced Hot Water **Lesson 4**

Objectives:

1. At the end of this lesson the student will understand how a hot-water system works.
2. The student will also understand seven factors important to planning or servicing a hot-water system.

Related Information:

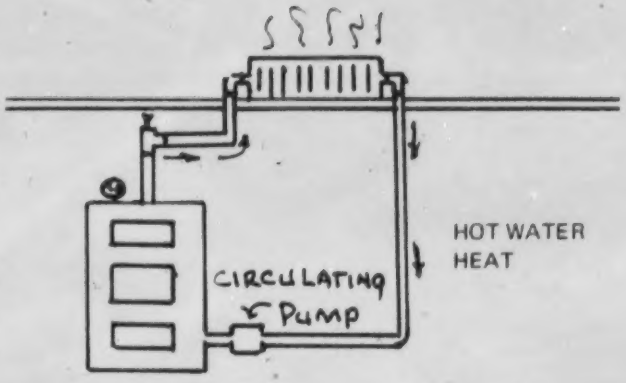
Until recently nobody knew how the hot-water heating system got started . . . and nobody really cared. Luckily for history and science, a little old science teacher cared and recorded the facts: these were recently discovered on a big stone just outside his cave.



According to the stone, hot-water heating got its start when water was used to cool off the first Fords. The water did more heating then cooling, and so one wise farmer by the name of John Whip decided to use it. He used the hot water to heat his henhouse and the steam to take frost off his pumpkins.

How he got the Fords into his cellar nobody will ever know, but he did. Whip heated his house with hot water, and that's how it all got started. And that's how that saying originated – "smart as a whip" – to pay him tribute.

The modern hot-water system consists of a series of coils or a water chamber in a furnace. The heat from the furnace passes through the coils or chamber by conduction and heats the water. This heated water is forced through the pipes by a circulating pump to the radiators. The heated radiators pass the heat off by conduction to the surrounding air and by radiation.



Radiators may be the cast-iron base type or the fin-type. The cast-iron radiators are bolted in separate sections so that the radiator area can be increased or decreased. The fin type consist of copper tubing with a series of metal fins attached to act as diffuser of heat. Cast iron is slower to heat up but retains the heat longer. The fin type has the advantage of supplying faster heat, but they cool off faster. The radiators are so designed that cold air enters at the bottom, then is heated and rises. This sets up convection currents that heat uniformly. An accumulation of dirt or a blockage of air by furniture reduces the efficiency.

The heat can be controlled by a single thermostat, or the house can be divided into zones and be heated by several thermostats. For example, a split-level home can be divided into a lower and upper zone. Each zone is handled by a separate thermostat and a separate pump – all from the same furnace. Frequently one area of a house needs more or less heat, depending on traffic, use, etc.

The major points to check when providing a hot-water system:

1. Install piping in as short and direct a method as possible to keep friction loss at a minimum.

2. Provide adequate radiation based on accurate heat-loss calculations.

3. Clear away dirt and obstructions from radiators.

4. Place radiation on outside walls.

5. Minimize heat loss by proper insulation of pipes passing through cold areas.

6. Provide an adequate circulating pump.

7. Locate thermostat properly.

UNIT VII – HEATING AND COOLING

Methods of Heating – Radiant Heat **Lesson 5**

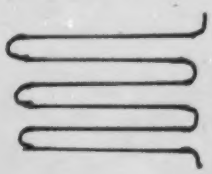
Objectives:

1. At the end of this lesson the student will understand how hot water, steam, or electric wires can produce radiant heating in the home.

2. The student will also understand how radiant heat from the sun can be used in home heating by special construction.

Related Information:

Coils of wire or pipe



Radiant-type heating

In recent years, heating homes with radiant heat has gained popularity. Radiant heat provides a more uniform heat and also eliminates radiators, ductwork, registers, and exposed pipes.

One method is to install a system of pipes in the walls, floors, and ceilings of rooms, using hot water or steam for heat. This method of heating provides a much greater heating surface and does a better job of heat distribution.

The hot water and steam systems use pipes that are embedded in the floors or walls. The floor system of pipes must be accurately and uniformly spaced to avoid cold spots. Careless installation defeats the purpose by producing uneven heat distribution. Radiant-heat systems are popular in slab-type construction where cellars are omitted. The pipes are embedded in the concrete slab.

The heating units for radiant heat use the same basic methods and materials as conventional steam and hot-water systems.

Radiant heating can also be accomplished by electrical heating cables embedded into the floors, walls, and ceiling. The operation and efficiency are equal to hot water or steam but the cost is generally higher.

Thus, radiant heat when properly installed requires less fuel or electricity than other systems and the maintenance costs are very low.

Radiant heat from the sun can also be used for heating an enclosed space. For example, if you go down to the shore and leave your heap in the sun with the windows closed . . . you have a mighty hot car to get into. This happens because the sun's rays get in, warm up the interior, but then the heat can't get out. Unless you provide ventilation through a window or a fresh-air vent, the expanding hot air can blow your windows out!

The same general idea – the so-called greenhouse effect – is used to heat homes by the radiant energy from the sun. The exterior walls must use glass blocks or large glass windows to permit the energy waves of the sun to pass through. The radiant waves warm up the contents of the house, which in turn warms up the air. Thus once the sun's heat enters, it is trapped.

Obviously this type of heating would have little use in rain forests, or during the winters in Alaska, when the sun might or might not put in an appearance for an hour or two a day.

UNIT VII – HEATING AND COOLING

Other Modern Methods of Heating **Lesson 6**

Objective:

At the end of this lesson the student will be acquainted with several other heating systems in use.

Related Information:

Some other modern heating systems are as follows:

1. **Electrical.** – There are various ways of heating with electricity. We saw that cables could be installed in floors or walls. In addition, electrical heating panels may be installed on or in the walls. Built-in electric heaters come in a variety of shapes and sizes. They come with and without fans, timers, and other refinements. Individual thermostats permit a wide range of control, and thus rooms can be individually heated depending on need.

New, total home installations depend on conforming to rigid insulation requirements set by the power companies. Because of the relatively high cost of electricity, insulation must be thicker; hence original installation costs are higher.

The advantages are clean, efficient heat with individual controls. Installation requires no bulky piping, ducts, or furnace – thus offering more space, speedy installation and minimum maintenance. Disadvantages are increased fuel costs, possible power failure, and possible power-supply shortages.

At present, electrical heating by windpower to supplement the electricity from the power company is arousing some interest. A few homeowners have installed wind-catching devices on their roofs or property, and use the rotating blades to generate electricity, which is then stored in storage batteries. At present all of these devices are still experimental.

2. **Heat Pump.** – This system removes heat from the earth instead of heat from burning fuels. A network of pipes is extended deep underground – perhaps as much as 12 feet. The heat pump then uses a liquid refrigerant that is pumped continuously, removing heat from the earth. Radiators distribute the heat as in any other system.

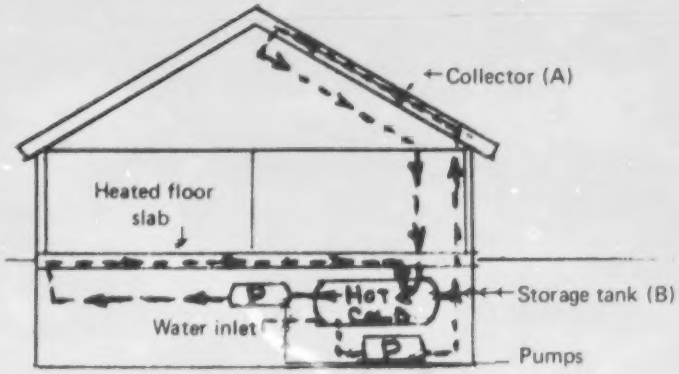
This system is only practical where winters are relatively mild. This factor plus the cost of installing pipes and the cost of electricity limit its popularity.

3. **Solar Heating.**–A solar-heating system depends on a collector on the roof that absorbs the radiant heat of the sun. The collector consists of one or two layers of glass plates (for insulation) that cover a network of black pipes circulating water. This network of pipes is set against a black-painted sheet-metal base; thus both combine to absorb the sun's heat.

A TYPICAL PLAN FOR SOLAR HEATING

Follow path of arrows

(A) Heated water goes to storage
(B) Storage tank provides hot-water heat



In the United States the collectors must face south and be tilted at an angle to receive maximum radiation from the sun. Thus, when the sun heats the collector, the system's thermostat starts circulating the warm water through the tubes into a storage tank. Once the hot water is stored, it is ready for immediate circulation or for storage for later use in the day or night. Circulation depends on pumps or blowers; hence the system is much like your conventional hot water furnace.

Solar heating is growing in popularity and should be in fairly wide use by 1984, according to scientific research. However, solar heating will require a supplemental source of heat, because on rainy or cloudy days the radiant heat is at a minimum.

(Warning) Don't start rat-packing old pipes, tin, and black paint, without telling your folks about this lesson. Most parents take a dim view of scrap-metal drives without a briefing on the value of solar heating.

4. **What next?** – Many people are experimenting with new ways of producing useful energy. Here is a field for science-minded people. Know anyone who'd be interested?

UNIT VII – HEATING AND COOLING

Types of Fuel **Lesson 7**

Objectives:

1. At the end of this lesson the student will realize that selecting a fuel depends on three main points.

2. The student will also realize the factors that affect fuel supplies.

Related Information:

Selecting a fuel is like selecting a girl friend – you have to consider *availability*, *cost* and *dependability*.

Domestic heating can be supplied by oil, gas, electricity, or coal, but you should make your choice well in advance of construction.

For example, gas pipelines are not always available, or the cost of running the service to the house may be too great. Electricity, for another example, may be available, but the power company in that area may have limited capacity. Therefore, your first consideration is to check locally and see what is available.

Secondly, the cost should be estimated from two points of view: first, the initial installation costs, and secondly, the fuel-consumption costs over the long range. For example, the costs of excavation, oil tank, and burner unit for oil heat may be initially high. However, the availability, cost, and efficiency in the long run might make oil a better buy for some.

Dependability in times of energy shortage is difficult to determine. Gas, oil, electricity, and coal may all be in short supply, with no ready solution available. Thus the wisest course is to get all the information possible about the local situation. As of the time this book went to press, there were many ....

Points to Ponder:

1. The cost and supply of heating oils depend on many factors, including international ones over which the individual has no control.

2. Oil suffers from delivery problems due to strikes and weather.

3. Electricity suffers from a lack of new electrical generating plants, and from generating and transmission breakdowns.

4. The demand for electrical energy is greater than the available supply even when things are normal, hence high costs.

5. The construction of new gas transmission lines and plants is often prevented or delayed by environmental pressures.

6. The gas supply is dependent on the oil supply to a great extent; hence both are short.

7. Gas and electrical heating were once greatly encouraged by utility companies. Now it is difficult to have an application accepted, due to energy shortages.

8. The growth of population and industry is at a faster rate than the growth of fuel production.

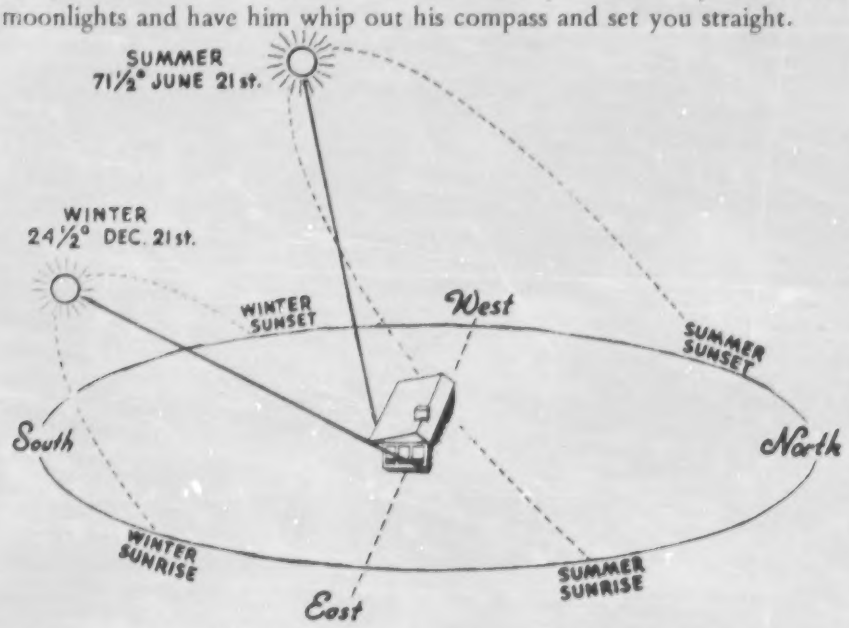
Weather Factors **Lesson 8**

Objective:

At the end of this lesson the student will understand that placement of the house can make a great difference in comfort and enjoyment of the home, and in heating bills.

Related Information:

If you don't know north from south and you think a compass is an 8-day clock . . . don't start construction. Get yourself a boy scout who moonlights and have him whip out his compass and set you straight.

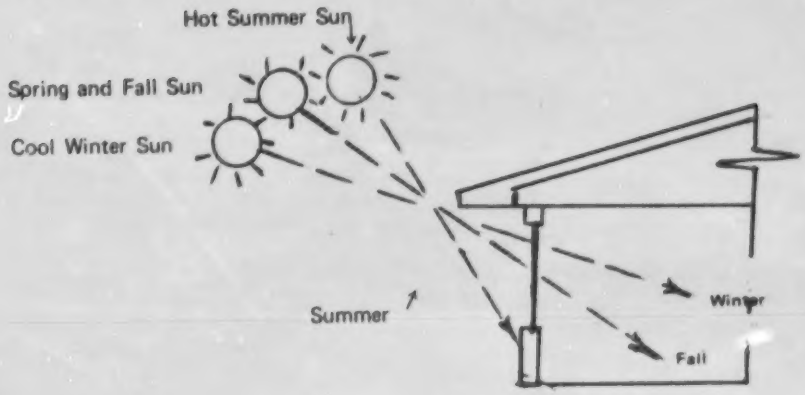


POSITION OF THE SUN AT NOON IN CHICAGO

Adapted from: *Physical Science, A Basic Course*, by Hogg, Cross, and Vordenberg. D. Van Nostrand Co.

That house of yours should be placed to provide maximum control and utilization of the sun's rays. A house in the northern hemisphere will always be warmer on the south and west sides than on the east and north sides. The south side has almost constant exposure to the sun and always is warm. The north side is always cooler because it's always in the shade.

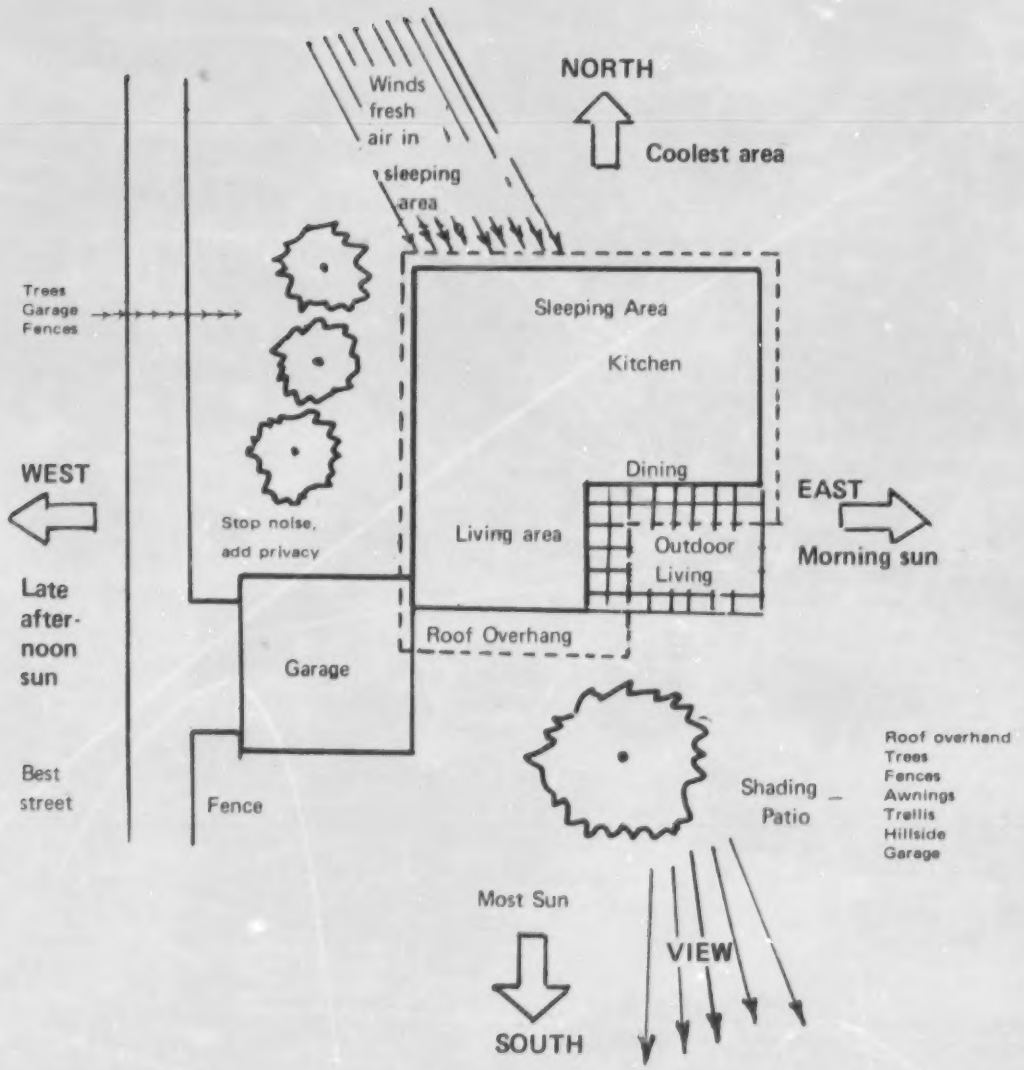
Once the boy scout shows you the points on the compass, pay him and get rid of him. These kids think they are experts in all fields and can confuse you.



Decide what rooms will benefit most from the sun and what rooms should be shielded from the sun. Areas that benefit from the sun usually use large areas of glass to take advantage of solar energy. The overhang is usually extended enough to shade the windows during summer, when the sun is high in the sky, but still allow the sun's rays to enter in the winter, when the sun is low in the sky.

A good design provides sunshine for the kitchen in the morning, then the living areas in the afternoon. Thus kitchens and dining rooms are best situated on the south or east side. Living areas benefit most from southern or western exposure, to take advantage of the sun. The north side is always coolest and darkest; hence it offers the ideal location for rest and sleep.

Trees and shrubs can effectively act as windbreaks against prevailing winds. Shade trees on the south side help keep the heat out in the summer but let the heat in during the winter.


NORTH
Winds
fresh
air in
sleeping
area
Coolest area
Trees
Garage
Fences
Sleeping Area
Kitchen
Dining
WEST
EAST
Morning sun
Stop noise,
add privacy
Living area
Outdoor
Living
Late
after-
noon
sun
Roof Overhang
Garage
Roof overhand
Trees
Fences
Awnings
Trellis
Hillside
Garage
Shading
Patio
Best
street
Fence
Most Sun
VIEW
SOUTH

Insulation Principles **Lesson 9**

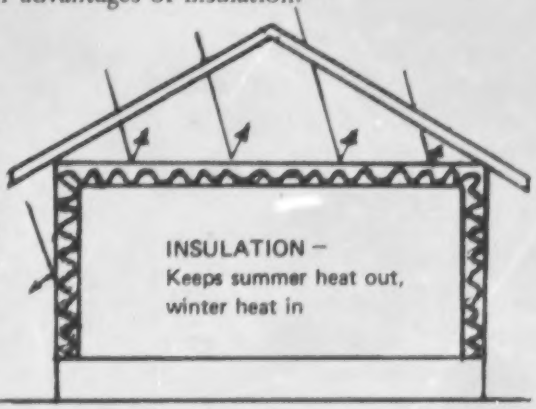
Objectives:

1. At the end of this lesson the student will understand how insulation resists the transfer of heat.

2. The student will also understand the other advantages of insulation.

Related Information:

The primary purpose of insulation is to prevent the transfer of heat. Heat, as you know, is transferred in three ways, and any kid old enough to hate school is an expert on all three. Let's review and prove that not all science comes out of books.



Review:

Heat can be transferred from a warm place to a cool place by conduction and/or convection and/or radiation. Right! Now, let's show that we understand the difference.

1. **Radiation:** Any kid with short hair, thin eyebrows, and no hat knows how the sun radiates heat. That's why kids hide in the weeds, under porches, and in the cellar. Not to get out of school, but to get out of the sun into the shade.

2. **Conduction:** Any kid that has walked on a hot sidewalk with bare feet knows it smarts something fierce. The hot sidewalk is conducting heat to the feet.

3. **Convection:** Any kid that has hung around a shopping center on a hot day has seen the "heat waves" that come off the blacktop and the roofs of cars. Smart kids wait until the convection currents of hot air simmer down.

Now, let's see what insulation does for a house.

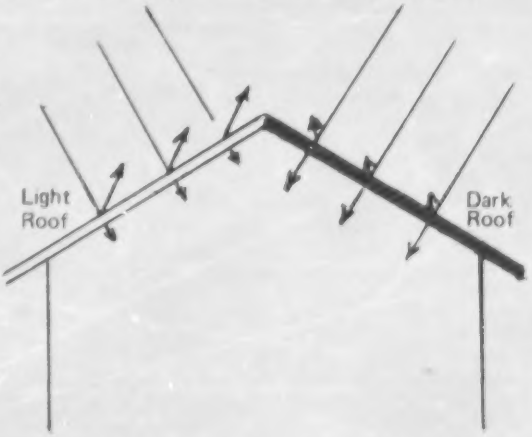
The enclosed spaces in walls cut down considerably on heat-transfer by *conduction*, and all materials used in construction offer some resistance to the transfer of heat as well. However, their resistance is low, and so a material with a high resistance must be used. Materials that have *many tiny air pockets* have a high resistance to the transfer of heat.

If air is such a good insulator, why not leave the walls of a house empty? Because if the walls are left empty, the difference in temperature between the cold (outside) surfaces and the warm (inside) surfaces sets up *convection currents.* The warm air is pushed up by the cold air, and the convection currents thus set up transfer the heat rapidly from the inner walls to the outer, and out into the great beyond. (The heat transfer is reversed in summer.)

Insulation instead provides tiny pockets of air that resist convection currents and hence retard the flow of heat. Wall insulation provides a small amount of free space that permits some passage of air but not enough to produce a great heat loss. And the loose material has so few points of contact that transfer of heat by conduction is not great.

The best insulation against *radiant* heat is a smooth, shiny surface, or at least a light-colored surface. This turns back much of the radiant heat just the way a mirror reflects light.

If you are planning on central air conditioning for your house, you can use a smaller unit if you have a light-colored house and light-colored roof.



Thus insulation provides its primary purpose of preventing heat transfer, plus:

1. **Comfort** — Insulation prevents rapid temperature changes that affect body comfort. Uninsulated walls can actually cheat you out of 30% of your living space by being too cold.

2. **Cost** — Insulation reduces fuel costs. A well-insulated home in the Northeast, for example, will save enough money on fuel costs to pay for the cost of the insulation in perhaps 2 or 3 years.

3. **Moisture** — Good insulation has a vapor barrier that reduces passage of moisture through the walls. Moisture creates rotting and damage, as well as carrying heat out with it.

4. **Fire** — Insulation retards the spread of fire by cutting down the drafts within the walls that spread fire so rapidly; and the materials themselves are often fireproof or at least fire resistant.

5. **Noise** — Insulation minimizes transmission of sound – cuts down street noises and keeps the noise from kids and rock music at a safe level for passers-by.

UNIT VII – HEATING AND COOLING

Insulating Materials **Lesson 10**

Objective:

At the end of this lesson the student will understand the composition and use of four popular types of home insulation materials.

Related Information:

There are many different types of insulating materials, and some are better suited for a specific area than others.

1. **Flexible insulation** is usually in the form of blankets or batts. Blanket insulation comes in continuous rolls or strips in various widths to fit standard stud and joist spacing. It comes in various thicknesses, too, and is usually made from wood or vegetable fibers, mineral wool, or glass fibers. Generally it has a paper covering and nailing tabs. One side of the covering usually acts as a vapor barrier. The batts are similarly made but come in 24″, 48″, and 96″ lengths.

2. **Fill insulation** is made in a loose form so that it can be poured or blown into place. Generally this insulation is made from mineral or wood fibers, vermiculite, or loose cork. In new construction it is used to fill the spaces between ceiling joists, plus spaces between wall studs that are hard to reach when installing blankets or batts. It is particularly useful for adding insulation to a building already constructed without insulation. It is also good to fill the cavities in hollow-block construction.

3. **Reflective insulation** consists of sheet material with a reflective surface on one side or both. Aluminum foil or specially treated metals are used for reflection. It is used in stud spaces or other areas where the reflective surfaces face an air space. The shiny surface should not touch another surface, or the reflective property is lost. Sometimes a corrugated paper is sandwiched between two reflective foils.

4. **Rigid insulation** is fiberboard material, manufactured in a wide range of widths, thicknesses, and lengths. These sheets are generally made from wood or vegetable fibers, mineral wools, or plastic. They usually combine heat- and sound-insulating properties with strength, through their rigid form. In home construction they are used as sheathing, roof slabs, and wall and ceiling decorative blocks, planks, and slabs.

There are many other varieties of insulating materials that are combinations of mineral, vegetable, and plastic materials. However, they have greater commercial than home-construction use.

UNIT VII – HEATING AND COOLING

Cutting Openings **Lesson 11**

Objective:

At the end of this lesson the student will understand that notching or drilling studs, plates, and floor joists must follow established, safe guidelines.

Related Information:

Some tradesmen are careless and others are very hostile, especially toward wood. These wicked persons notch and drill holes in studs and joists with reckless abandon.

Unfortunately, this sort of thing can structurally affect the strength or life of the building. Notching and drilling should follow established guidelines based on science.

For example, as we saw in an early lesson, a floor joist is acted upon by two opposing stresses. The top of the joist is in compression and the bottom under tension. The strength of the material lies in the upper and lower fibers. Cut the fibers and you automatically cut the strength. If small holes are to be made in joists, they should be located in the center. The center is the neutral point between compression and tension and is safe to drill into. The cut, however, should not exceed ⅓ the total width of joist. Any greater reduction in joist strength should be compensated for with extra framing.

Notches for pipes may be made as long as they don't exceed 1/6 of the joist depth. They also must be placed in the end quarter of a span. Notch only for the diameter of the pipe plus a whiz for clearance.

Vertical studs may be notched as long as the notch does not exceed 1/3 the total thickness of the stud. Should the top plates of a wall have to be cut for piping or duct work that exceeds more than 1/2 their width, 18-gauge steel straps should be used across the opening for reinforcement.

The following tips are for folks that want to be foremen, superintendents, or just plain super-persons.

1. If your heating system has a persistent whistling sound – check the cellar. It's usually one of the workmen left behind.

2. If you hear a hum, don't call out the National Guard; it's just a pipe snugged too tight to the joist, as a rule. Trace down the hum and insert a piece of felt between the pipe and the clamp. (Use your father's old felt hat and blame it on the dog.)

3. Nail steel mending plates over all pipes in the wall or studs that could be struck by nails.

4. Always cut and drill holes a whiz larger than the pipe to allow for expansion and contraction. With duct work allow ½" clearance all around.

5. Ducts should be supported by strap hangers as they cross floor joists. Remember, metal expands and contracts and needs room. Creaking and groaning are usually caused by friction of metal on wood – or maybe somebody's sick at your house.

6. Hot-water risers and returns for radiators are frequently fitted too tight. This sure keeps out dust, drafts, mice, lizards, and frogs but it does create noise. Hot pipes expand and create friction and noise. Keep out of hot water yourself, or you may expand just where you didn't want to.

UNIT VIII – ELECTRICITY

Electricity as a Servant **Lesson 1**

Objectives:

1. At the end of this lesson the student will realize how important electricity is to us all.

2. The student will also understand that electricity can also cause fires, kill, and destroy property.

Related Information:

Electrical power is like having a thousand servants waiting on you hand and foot. It lights up your home, fills it with weird sounds called music, heats, entertains, cooks, cools, cleans – you name it.

Actually it's a lifeline, and this can be demonstrated by what has happened during blackouts. The last power failure lasted so long that many people were threatened with malnutrition and starvation because electric can openers and stoves were useless. There were no sweet sounds of rock music, and the stillness drove some folks into fits of depression and others into violence.

It was a mad scene: folks stopped shaving, bathing, washing their clothes, and using hot combs. Everybody was outside barbecuing spare ribs and chicken, and the pollution was something fierce. Even down on the farm, milking machines stopped, and babies, cats, and dogs were yelling, meowing, and barking real loud. Get the picture?

One week without electric power and this great country of ours would come to a screeching halt. Water would not be pumped; food could not be saved from spoiling; and lack of power would shut down every manufacturing plant.

But it must not be allowed to happen. Occasional power failures prove that in many areas the demand exceeds the capacity of the supplying generators. Lack of new generating plants, overload breakdowns, and fuel shortages paint a poor picture for the future. Electrical power might even reach the point of shut-downs or rationing – so *conserve energy at home, school, and on your part-time job.*

More than any other force in history, the electricity that we take for granted has changed the world and the people in it. Just the changes since you were born are fantastic – and would you believe that electricity as a servant is in its infancy?

Electricity runs our homes, farms, hospitals, industry – even schools! All this service with no danger to the user *if properly used.* Yet, this servant can also run wild and cause fires, kill people, and destroy property. Remember all this beautiful service – but only *under control.*

What Is Electricity? **Lesson 2**

Objectives:

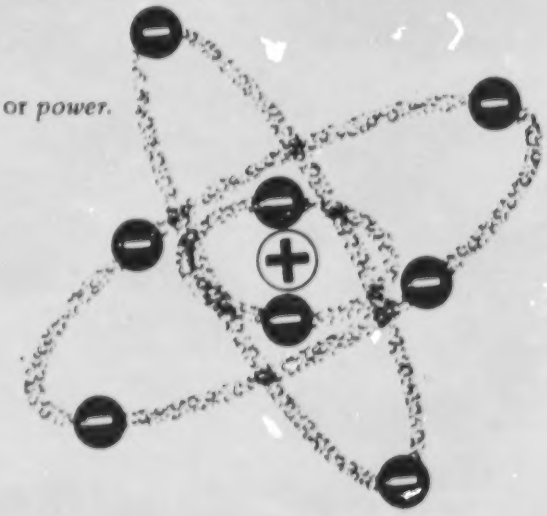
1. At the end of this lesson the student will understand some of the fundamental facts about electricity.

2. The student will learn about overloads, short circuits, fuses, and circuit breakers.

Related Information:

What is electricity? Electricity is a kind of *energy* or *power*.

You know by now that all substances, whatever their nature, consist of molecules, and that the molecules consist of atoms. Every atom of every substance is a bundle of energy. Each atom consists of a central *nucleus* surrounded by whirling bits of energy called *electrons*. These travel at enormous speeds around the nucleus.



One way of picturing an atom

Some substances, particularly certain metals, have electrons that easily escape from their atoms. When these electrons move from atom to atom through wires, we have what we call a *current of electricity*. We could say, very briefly, that *an electrical current is produced by the movement of electrons.* Although any one electron, moving from atom to atom, may cover just inches per second, the electrical current itself travels at the speed of light, or 186,000 miles per second!

To try to get a better idea of how an electrical current flows almost instantaneously, set up a line of pennies as shown in the illustration here. Now knock a penny into the head of the line. What happens?

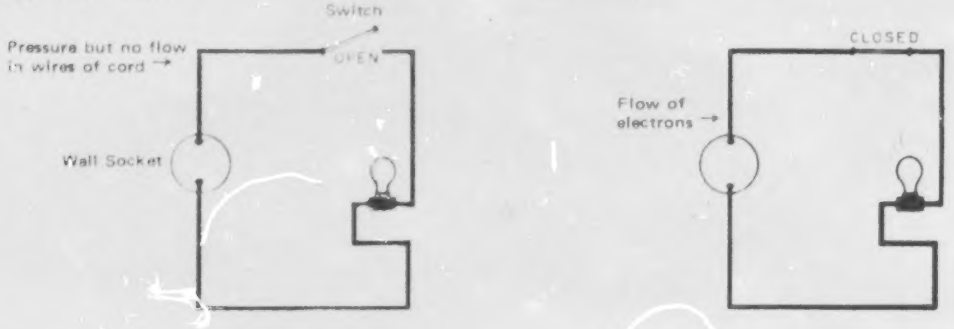
Instantly, the *last* penny is knocked away. All the other pennies move scarcely at all. Similarly, electrical current is the force produced by relatively small movements of electrons.

Certain materials that have electrons that escape easily are called *conductors*. All metals are conductors. Silver is the very best conductor and copper is next best. We can define conductors by saying *conductors carry electricity*. Certain materials "hold on to" all their electrons very tightly, so that it is very difficult to dislodge them. We call this type of material a nonconductor, or *insulator*. Rubber, glass, and wood are some good insulators.

Electricity is produced in huge generating plants, which through a miracle of science can convert *motion* into *electricity*. The motion may be produced by vanes pushed around by steam in a turbine, or by some other means. The miracle happens when conductors (wires) cut rapidly across magnetic fields, and – presto! – out comes electric power. This power comes to your home from the generating plant in high-tension wires, and is available for your use any time you turn on a switch. But until you turn on the switch, nothing happens.

Suppose you buy a nice new extension cord and plug it into a wall socket. Will electricity flow through it? Nope. But suppose you have an extension cord plugged into a wall socket at one end and a lamp at the other end. Will electricity flow through it? It will flow *as soon as you turn the light on*.

What is the difference? For electricity to flow, you need first to give the electrons a "push" ● and this comes from the electricity flowing through the wires of the building. You get it through the wall socket. The "push" is called *voltage*. But you also need a *complete circuit*, that is, a pathway of conducting material that has no breaks or gaps in it. In this case, the switch on the light closes the pathway, the electrons rush along, and the light lights up.



In other words, if you have a conductor attached to a source of electricity, current will flow through the wire *as soon as the circuit is completed*. IF YOUR BODY is the thing that completes the circuit, the electricity will flow through YOU. (The body is a good conductor.) Depending on the strength of the electrical current, the electricity can give you a mild shock, a severe shock, or a fatal shock.

We said that the "push" on the electrons is called voltage, and we know that our appliances are designed to operate on a certain voltage – usually about 115 volts for light appliances and 230 volts for those that use a lot of electricity.

The actual *amount* of electricity flowing through the wires is called *amperage*. We say that an appliance uses ("draws") say, 10 amps.

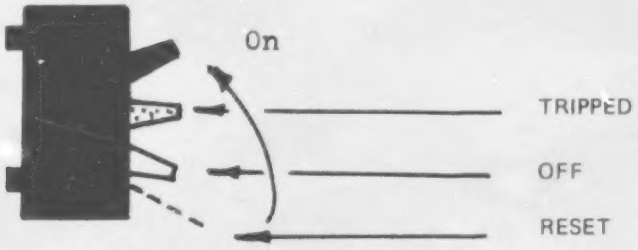
We pay our electric bills according to the *wattage* we have used.

No. of watts = no. of volts X no. of amperes

Every kid knows that pushing and shoving create heat. Well, the pushing and shoving of electrons in wires creates heat, too and the smaller the diameter of the wire, the more heat a given flow of amperes will produce. If for some reason we increase the flow beyond what a wire was designed to take (say we plug a toaster, an electric coffeepot, and a broiler into the same circuit), the wire promptly becomes much hotter than it should be. If we don't have a fuse or circuit breaker to open the circuit for us, we could have a fire in our walls in no time flat.

What actually happens when a fuse blows? The electricity in a particular circuit always passes through the fuse for that circuit. The fuse includes a small section of a soft, low-melting-point metal. If the amount of current drawn through the line becomes more than the line was designed to carry, this "weak point" in the line will melt, breaking the circuit. *Before replacing a fuse*, determine why the current became too great (too many devices turned on?) and remedy the situation. Otherwise the fuse will just blow again.

A circuit breaker contains a strip of metal that expands a lot when heated. If an overload occurs, this strip expands, lifts off its contact point, and breaks the circuit. The circuit breaker is put back into service by its switch.



There are other ways to blow fuses or trip circuit-breakers besides plugging in too many appliances. You can create *short circuits*. You don't have to study a lot of books to figure out how to make short circuits.

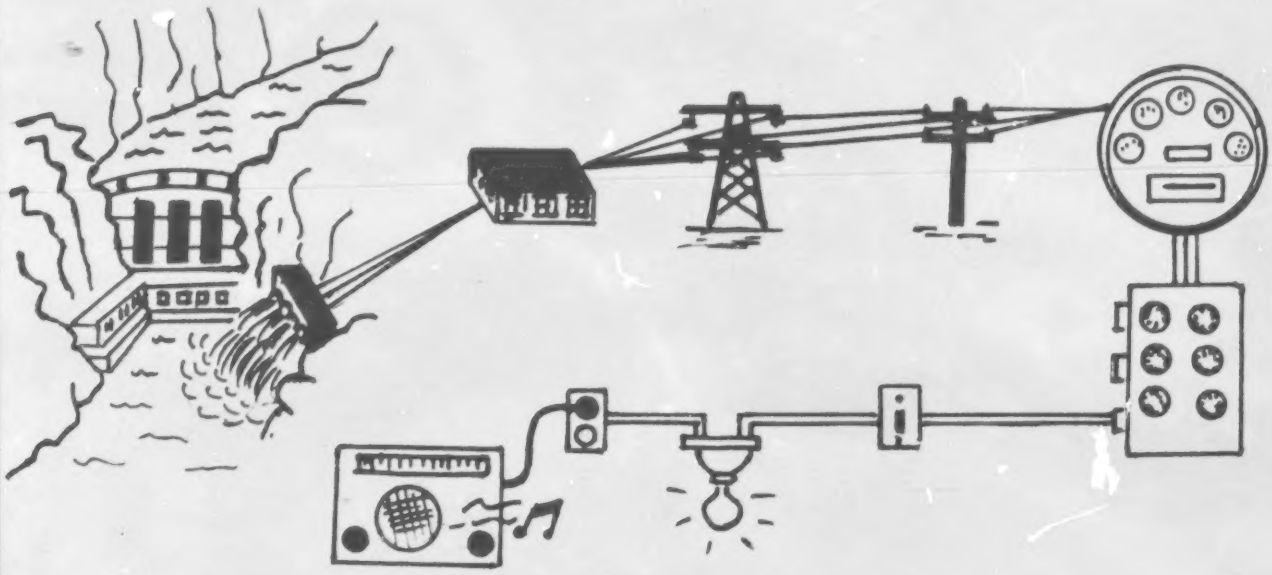
Just rub the insulation off an extension cord, so that the two wires in the cord come together. That way the current by-passes the appliance – it takes a shortcut. The circuit is completed without having the amount of current cut down by going through the appliance. Bingo. The extra amperes rush to the fuse, heat it up, and there goes your fuse.

The moral of this story is – there is more than one way to get into trouble with electricity. Pay attention to this unit and you can avoid them all.

Adequate Wiring Lesson 3

Objective:

At the end of this lesson the student will understand why the home should be adequately wired.

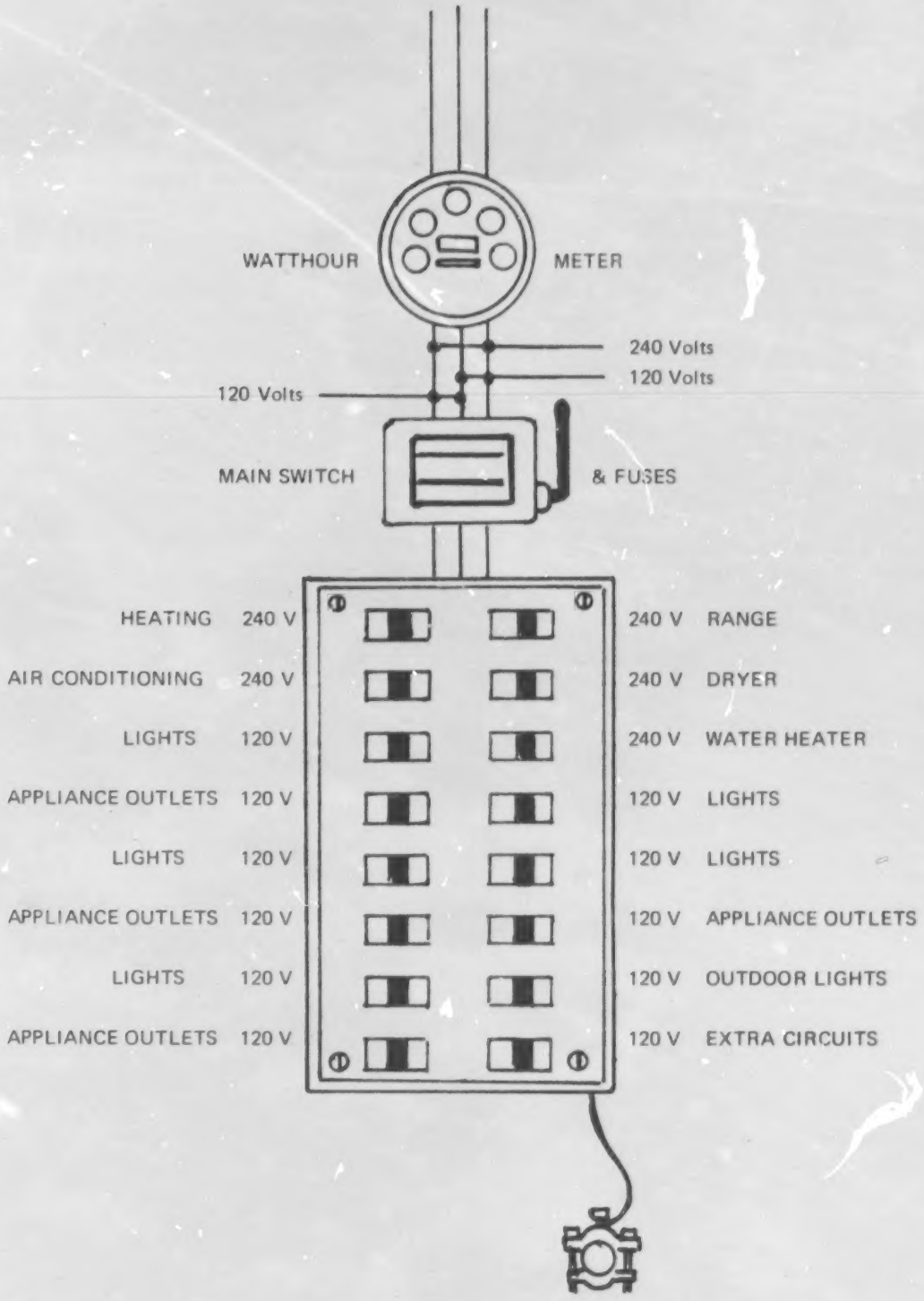


Related Information:

The electricity that you use is generated in power stations located in the boondocks. The power is then transmitted above the swamps, weeds, and bushes, through high-tension cables to your ranch home, log cabin, or teepee. The steel towers used to support these high-tension lines are built especially high to keep frogs from jumping up and shorting the wires. As a matter of fact, frogs are said to be the cause of several recent blackouts and power failures.

This valuable lesson is concerned with adequate wiring in your home, and so who cares how electricity gets there? Who cares, I ask you, about the power scene with the high ceilings, swamps, and weird frogs. Forget it; let's start at the house and explain adequate wiring.

An adequately wired home is one that has been wired so that you receive the maximum utility and the minimum of trouble. You should be able to plug in lamps, radios, tape players, and other electrical gadgets without a network of extension cords. You should be able to turn on the lights in any room without stumbling over furniture in the dark to find the switch or pull chain. You should be able to plug in one appliance without unplugging another. Fuses should rarely blow, and lights should not dim when you plug in a heating element.



ELECTRIC POWER IN THE HOME

Adequate wiring must be planned not only for today's needs, but with one eye on future needs. For example, not too many years back, a 100-watt bulb was a big deal and used only on special occasions. Today floor lamps with 300-watt bulbs are common. Then how about the radios, televisions, toasters, heaters, cleaners -- as a matter of fact, most homes have two of each. To complicate matters, most modern homes use air conditioning, fans, washers and dryers, dishwashers, and outdoor lighting.

House power starts with the service entrance, which includes all wires and equipment from the outside of the house up to and including the meter and main switch. The service entrance must be of sufficient size to handle the maximum electrical load without causing a voltage drop or blown fus. For example, 30 to 40 years ago a 60-amp service was used; today a house should have at least 100-amp service. Thus, as the use of electricity increases, the minimum must be raised to take care of the present and the future.

Once in the house, the electric power is distributed from the main switch into branch circuits. Each circuit handles a portion of the load, and each is protected by its own fuse or circuit breaker. Then, if one circuit is overloaded and the fuse blows, the rest of the house will continue to function. Imagine what would happen if all the lights went out at once! (The kids would get stomped on first.)

UNIT VIII – ELECTRICITY

Codes (National Electrical Code) **Lesson 4**

Objectives:

1. At the end of this lesson the student will realize the importance of the National Electrical Code in home safety.

2. The student will also understand that local codes and ordinances must be complied with.

Related Information:

The National Electrical Code provides the safe and legal guidelines for electrical installations. The code is the result of united efforts by the various insurance, architectural, electrical, and other interested groups. Thus, the code is simply a set of rules which outlines the materials and wiring methods that have been found safe and sensible through experience. The code permits installations in several different ways; however, all wiring must be done in one of the ways set forth by the code. New, updated codes usually appear every 2 or 3 years.

Many communities have their own local electrical codes and ordinances. These may actually be more strict than the National Code. For example, Bx (metallic cable) is approved by the National Code, but sometimes is prohibited by the local code. Some local codes are extremely rigid and are actually designed to discourage low-cost housing or mass-production of homes. Such restrictive codes can limit the number and raise the cost of homes, and thus maintain a high-cost exclusive residential area.

It is necessary and helpful to study the code prior to an installation. However, the code alone will not teach you house wiring. The purpose of the code is to safeguard the persons, buildings, and contents from electrical hazards.

The National Electrical Code does not in itself have the force of law, but indirectly you have no choice but to follow the code. For example, cities and states pass laws requiring all wiring to conform to the National Code. As a rule, the power companies will not furnish power unless the building is properly wired. Finally, insurance companies have a vital interest at stake and will refuse to issue insurance policies if the building is not properly wired, because it involves an extra risk. Thus, local codes, power companies, and insurance companies literally force you to comply with the code.

Some folks are sneaky and violate some code specifications. They make additions and changes after all inspections are made and take great pride in beating the system. However, if such a violation causes a fire, and if inspection proves a violation, the insurance company can refuse payment or cancel the policy. For example, if you finish off your attic or basement without an electrical permit or inspection, you could have insurance problems. First, your policy could be canceled if code violations exist. Secondly, should fire-damage result, your claim could be questioned, especially if electrical work was done in violation of national and local codes. Any electrical additions should therefore be inspected and approved to keep within the code and law.

Electrical Codes (Local Enforcement) **Lesson 5**

Objective:

At the end of this lesson the student will understand that most electrical work requires a permit, inspection, certification, and a license to operate.

Related Information:

Permits. Permits may be a nuisance, but a system of recordkeeping, application-approval, and organization are necessary to safeguard the public's welfare. Thus in many places it is necessary to get a permit from town, city, county, or state authorities before a wiring installation can be started. There usually is a small fee and a written application required. The fee money is usually used to pay the expenses of the electrical inspectors who see to it that the wiring is safe and properly installed.

Inspections. Once the permit is issued and the rough wiring is installed, the building is ready for a "rough" inspection. The home-owner or electrical contractor calls for an inspection. At this point the electrical inspector makes an inspection of the wiring and outlets, and approves or disapproves. If the work is approved, an inspection certificate is issued and is usually pasted in a front window.

If all other inspections for framing, plumbing, etc., are made and the electrical work is passed, then the walls may be insulated and covered. When all electrical work is completed, the inspector is requested to come out and give a final O.K. If the final certificate or inspection is approved, the power company will bring in the power. Power companies will not furnish power until an inspection certificate has been turned in.

Licenses. Many cities and states regulate electrical installations and installers and require the electrician to be licensed. Thus, to be engaged in the electrical contracting business, you must be licensed in most communities. Wiring your own premises, however, does not require a license Even so, you must obtain a permit, meet inspections, and follow the electrical code. After all, your own safety is just as important as the next guy's.

UNIT VIII – ELECTRICITY

Material Safety Codes **Lesson 6**

Objectives:

1. At the end of this lesson the student will understand why electrical parts of every description should be standardized in size and meet certain quality tests.

2. The student will also know that Underwriters Laboratories Inc. is the accepted organization for testing, standardizing, and setting guidelines, and what the UL label means.

Related Information:

Imagine the wild scene that would take place in discount stores if the thousands of manufacturers of electrical parts each did their own thing. There would be a "skillion" types of wall outlets, some probably the size of a door. No two manufacturers would make the same product, and quality would be impossible to judge.

Manufacturers, insurance companies, and other interested groups recognized the problem early. Thus, they joined forces and formed Underwriters Laboratories Inc. This consists of a group of electrical laboratories that standardize and test products.

Manufacturers can submit their products to the Underwriters for inspection. These products are then tested, and if they come up to the minimum safety standards they are "listed by Underwriters." In addition, the Underwriters regularly test random samples obtained from manufacturers or bought in stores. If the samples meet the required standards they continue to be listed with Underwriters. This listing is extremely important to manufacturers, and so they generally do their best to satisfy these standards.

Therefore, when buying or installing electrical parts, wire, or appliances, look for the Underwriters label. Some items are labeled plainly, other devices, such as receptacles, switches, etc., carry the words "Und. Lab. Inc. List" – molded or stamped on each piece. Appliances such as toasters, irons, etc., usually have a name plate; others carry a tag or marker. At any rate, every single item in some way or other has a sign of approval.

"Listed" does not mean the product can be used for every situation or in any way. "Listed" means that the product is suitable and safe if used *for the purpose for which it was intended.* For example, a fly swatter you just purchased may be okay for flies and small moths, but was not intended to ward off lions or rhinos.

In addition, "Listed" does not mean that two similar products are of the same quality. It merely means that the product *meets minimum safety standards as set forth by Underwriters Laboratories.*

UNIT VIII – ELECTRICAL

Common Sense and Safety in Planning **Lesson 7**

Objective:

At the end of this lesson the student will understand how common sense and the guidelines furnished by the National Electrical Code are the basis for safe electrical practices.

Related Information:

Any student that has sneaked, skipped, or stomped through high school corridors should know enough about basic house wiring for safe living. So, if you don't care for sparks, weird flashing lights, and buzzing in your hat rack, then you'd better pay attention. The following is a short electrical trip through a house, based on common sense and code guidelines.

A properly wired home has wall switches so placed that you can walk from one end of the house to the other without ever being without lights. Can you stomp through your own front door on a dark night, go through the house, and come out the back door without ever being in the dark? Well, if you can't and get lumps on your head for trying, then communicate with your "paw" and get it fixed.

It costs very little to install wall switches instead of pull chains or table lamps. In certain areas such as attics or cellars, three-way switches are a must for safety. This permits the light to be turned on or off from two different places; this will extend your life span – just like quitting cigarettes.

Install plenty of wall outlets, properly spaced, so that you never need an extension cord to operate a lamp, radio, clock, or similar device. Extension cords on the floor are like invitations sent to the undertaker or the fire department. Follow the code recommendations and place outlets along usable walls no more than 6 feet apart. This is a *minimum* not a maximum; therefore in living rooms add additional outlets for safety and convenience.

Wire sizes are specified in the code. This is one area where *no shortcuts should be taken.* The code requires that no wire smaller in diameter than No. 14 be protected by a 15-amp fuse or circuit breaker. Actually it is better to use a No. 12 wire with a 20-amp protection, because it will yield brighter lights, waste less power, blow fuses less often, and be safer all around. The difference in cost is like getting a double dip of ice cream for a penny more than a single . . . so what will you have, a single or a double dip?

Now let's take a tour through a house, snooping around as we go:

1. **Living room.** This should have a minimum of 6 wall outlets, to take care of radio, TV, clock, floor lamps, vacuum, plus a spare. *If lighting depends on floor and table lamps,* these outlets should be controlled by *wall switches.*

2. **Dining room.** Here a switch-operated ceiling outlet should be furnished, and at least 4 wall outlets. There is a large variety of small appliances available for dining-room use; also most appliances these days have shorter cords. The cord length is due to the Underwriters recommendations, and is meant to prevent you from using long, clumsy appliance cords that invite accidents.

3. **Kitchens.** The average housewife and her school-age "chow hounds" spend more time in the kitchen than in any other room in the house. Thus you need a ceiling fixture controlled by a wall switch for general lighting and general snacking. If the kitchen has more than one entry door, a three-way switch should be used near both doors. A work light should be furnished above the sink or work area. (**Note:** If the fixture is located where a person can touch the fixture and the water faucet at the same time, use a porcelain-type fixture, *not metal*). Provide for wall outlets about every 3 feet above counters, and provide outlets for the following: stove, oven, refrigerator, and clock. Wall and range fans should be wired directly into the house circuits.

4. **Bathroom.** Provide one ceiling light, switch-operated. Also provide a light over the medicine chest or mirror, plus one or two wall receptacles for shavers, toothbrushes, water pics, etc. *Do not put wall plugs in tub or shower area,* unless you have reserved several plots in a convenient cemetery. (Water is a great conductor of electricity. If you are standing in a tub or shower, you should never touch an electrical device. And people have been electrocuted when a small radio accidentally fell into the bathtub.)

5. **Miscellaneous.** Furnish light for all stairs and entrances. Furnish waterproof sockets for outside work or pleasure. Basements should have sufficient ceiling lights and wall plugs; they should be well lighted, as they are famous areas for injuries.

Absorb this lesson well or buy a cave and use fireflies. It's the only other path to safety.

UNIT VIII – ELECTRICITY

House Circuits **Lesson 8**

Objectives:

1. At the end of this lesson the student will understand why separate circuits are required in different parts of the house.

2. The student will also understand how the number of circuits is figured.

Related Information:

In a previous lesson we stated that the National Electrical Code should not be used as an instructional guide. Now we will see why.

As far as the code is concerned in residential work, you may place as many outlets as you please on one circuit. However, if you put too many on one circuit, the breaker will trip or the fuse will blow frequently. Therefore, even if you furnish enough circuits according to the code, overloading any one circuit is a poor policy. In most cases you would not want to connect more than a dozen outlets on one circuit, even though the code does not restrict this.

The circuits used in homes can be divided into three main types.

1. Lighting circuits. These circuits are intended primarily for lighting, receptacle outlets for radios, television, clocks, etc., as well as permanently installed lighting fixtures. The code requirements are based on the square footage of living space and furnish a safety guide. For example, the code requires enough lighting circuits so that 3 watts of power will be furnished for every square foot of floor space.

   Thus, a lighting circuit using the normal No. 14 wire and protected by a 15-amp fuse provides 15 x 115, or 1725 watts. (Note: We multiplied 15 amperes by the house-circuit volts to find wattage). Next, the total wattage of 1725 is divided by 3 (watts per square foot); this equals 575 square feet for one circuit.

   Bear in mind that this is the code *minimum* and is based on safety only. This minimum of one circuit for every 575 square feet will probably not furnish convenience and utility, nor does it provide for the future. It would be wiser to allow a lighting circuit for every 500 square feet or, better yet, every 400 square feet if possible. Man, electricity is like education – you have to consider the future.

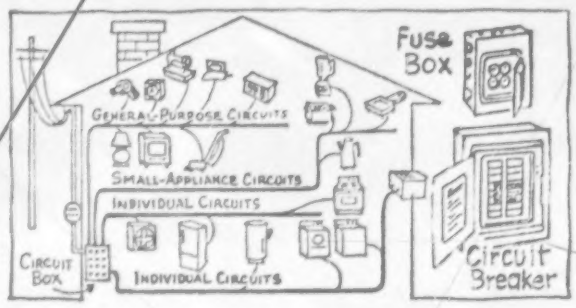
2. **Special appliance circuits.** A separate circuit should cover the kitchen and pantry; another should cover dining room and breakfast room; and a separate one for the laundry. This is the area where appliances that consume the greatest amperage are used. The code requires that the receptacle outlets in these areas be on a separate circuit, serving no other purpose whatsoever. This circuit must further be wired with No. 12 wire and protected by a 20-amp fuse or circuit breaker.

   The reason for providing extra wattage capacity is simple — the appliances take more wattage to operate. For example, the average toaster, steam iron, or similar kitchen appliance often requires 1,000 watts or more. An average roaster requires 1,650 watts.

3. **Individual appliance circuits.** These are circuits that serve a single, permanently installed appliance, such as a range, water heater, automatic washer, dryer, etc.

   The following appliances normally require a separate circuit for each:

   1. Range
   2. Water heater
   3. Automatic washer
   4. Automatic dryer
   5. Dishwasher
   6. Furnace
   7. Water pump
   8. Air conditioner



UNIT VIII – ELECTRICITY

Wire Materials and Sizes **Lesson 9**

Objectives:

1. At the end of this lesson the student will understand the reasons for using certain materials for wires.

2. The student will also understand how inadequate wiring wastes power and heat and can cause appliances and lamps to work poorly.

Related Information:

You could compare the flow of electricity through wires to water flowing through pipes. It flows more easily through some materials than others. For example, copper is the best material for ordinary purposes. Silver is even better, but hardly practical for everyday use. Aluminum is third in ability to carry a current. Now iron wire is cheaper, but if it were used, the wire would have to be about 10 times as big across as copper wire to carry the same amount of electricity. Wire that big and that heavy would create some mighty problems – especially for kids. In order to make toast you would need your kid brother to help you carry the toaster and plug it in. Those kids without a kid brother would have to eat spongy white bread or brown it with matches.

Actual diameters of sizes of copper wire without the insulation

Copper-wire sizes are indicated by a number. For example, No. 14 is the wire size most often used for house wiring; and it is slightly smaller than the size of the lead in a pencil. Numbers *smaller* than 14 (12, 10, 8, and so on) are *larger* in diameter than No. 14. The greater the load or the amperage, the lower the number and the thicker the wire that must be used. Thus, just like water, the bigger the job, the bigger the pipe. You wouldn't expect to serve every house on your block with a garden hose as a main. Well it's just about the same with wire.

Numbers larger than 14, such as 16, 18, 20, are used mostly for flexible cords and the real fine wires for small motors and appliances. Number 14 is the smallest size permitted by code for ordinary house wiring.

The correct wire size must be used for two important reasons: *carrying capacity* and *voltage drop*. When electricity flows through a wire, it creates a certain amount of heat. The more amperes flow through the wire, the greater the heat. For example, if you double the number of amperes flowing through a given wire, the amount of heat increases four times. This heat is wasted energy, and, if the wire isn't big enough to "take it," it can damage the insulation or even cause a fire. Thus to avoid excess heat and wasted power, we must use the proper wire size.

The electrical code, as explained in a previous lesson, is not concerned with wasted power but with safety. Therefore the sizes recommended are based on maximum amperage that various sizes and types of wires are allowed to carry.

A second important consideration is voltage drop. This means that the voltage is less at the appliance or lamp than at the service box, and hence it does not operate at peak efficiency. For example, a voltage reading at the main switch would be 115 volts, but in traveling through a No. 14 wire for 50 feet it would drop to 110 volts. This voltage drop is very important, because appliances work very inefficiently on voltages lower than they were designed for.

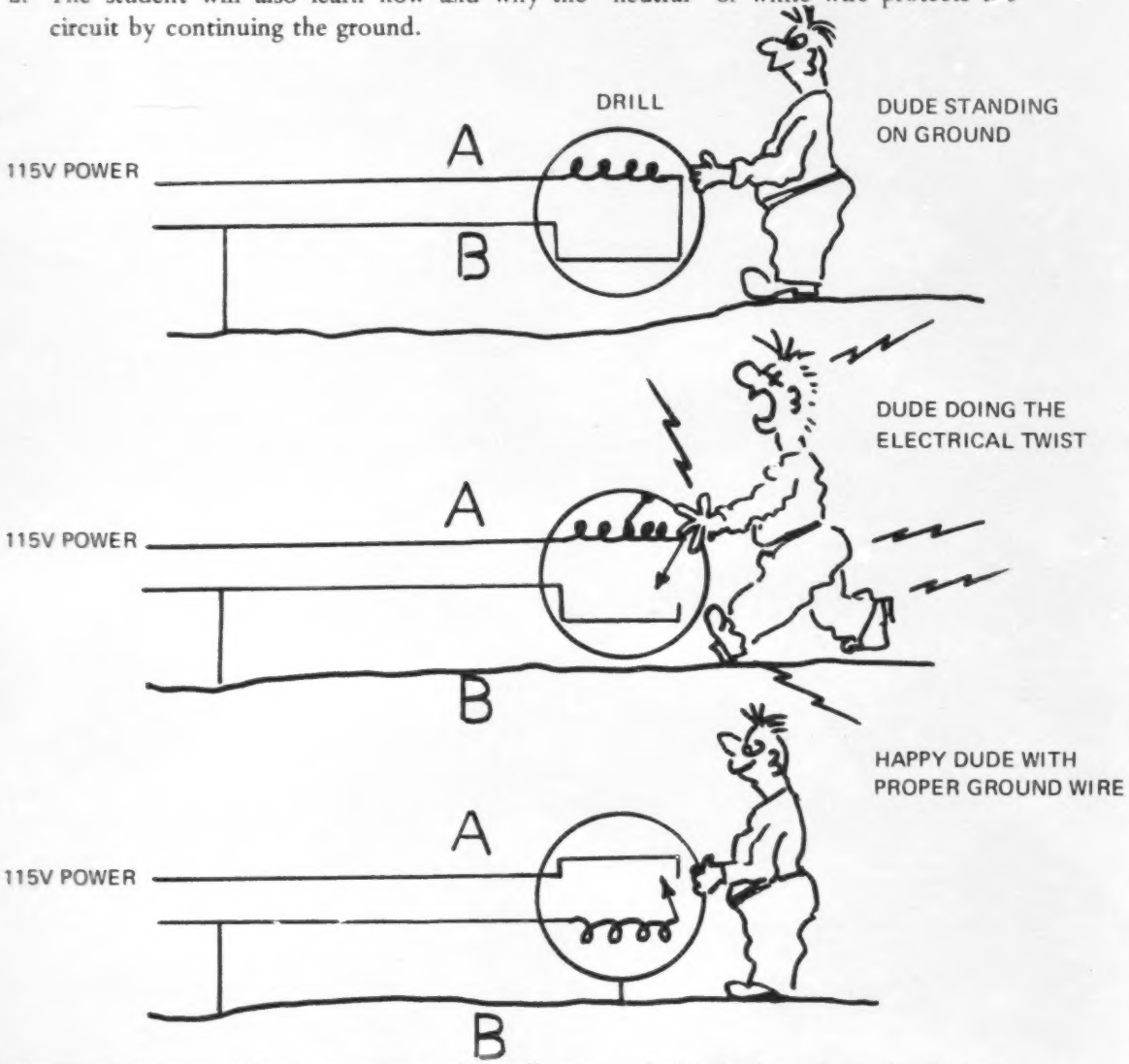
Thus, the wobbly desk lamp in your room could be producing only 70% of the light it should produce. No wonder that students have trouble doing their homework! Just try telling your teachers that you couldn't do your homework because the wires were too small, and the voltage-drop affected your wobbly lamp. The average teacher won't buy it and will either throw paper clips at you or tell you to get lost. But give it a try anyway. Any time your homework suffers, refer your teachers to this lesson . . . it should work at least once.

Grounding **Lesson 10**

Objectives:

1. At the end of this lesson the student will understand what the term "ground" means and its purpose – to prevent shock.

2. The student will also learn how and why the "neutral" or white wire protects the circuit by continuing the ground.

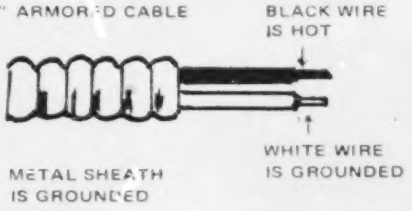


The term "ground" is frequently used in all types of electrical work, and yet many people don't know what it means or why a ground is needed. Well, that's what this lesson is all about. A sound knowledge of grounding can be the difference between being *on* the ground or *in* the ground . . . yup, if *you're* the "ground," it can be fatal.

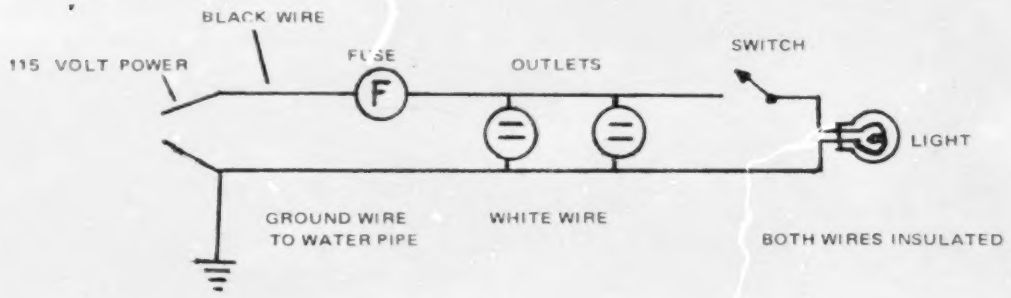
Grounding simply means connecting a wire or piece of equipment to something through which the electricity can flow harmlessly into the earth. In homes this is usually done by connecting the ground wire to a water pipe or to an "artificial" ground (a long metal rod driven deep into the earth). At the meter where the power lines enter the house, a heavy-gage ground wire is connected to the nearest cold-water pipe. The water pipe is a good ground, because it is in contact with the earth for a considerable distance.

It is important to ground not only power lines, but all individual appliances with a metal framework. Let's assume for the moment that you are using a drill press that is *not* grounded. If a little of the insulation has worn through, so that a bare wire touches the outer metal of the press, the entire frame would become "hot" – charged with electricity. You would have no way of knowing this, as the machine would probably still work. If you were to touch the metal, however, you would get a severe shock. If by chance you were standing on a damp floor at the time, the electricity would surge through you and into the ground, and you might not live to investigate what happened. On the other hand, any such defect happening on a *grounded* drill press would simply blow a fuse, alerting you to the fact that something went wrong in your drill press.

It is not only worn tools and appliances that develop "leaks" of electricity. A brand new tool may be defective and cause just as much grief.



To summarize: Electricity packs a mean wallop, and so the system has to be grounded at its entry into the house; each branch circuit must be grounded; and finally, all tools and appliances must be individually grounded.



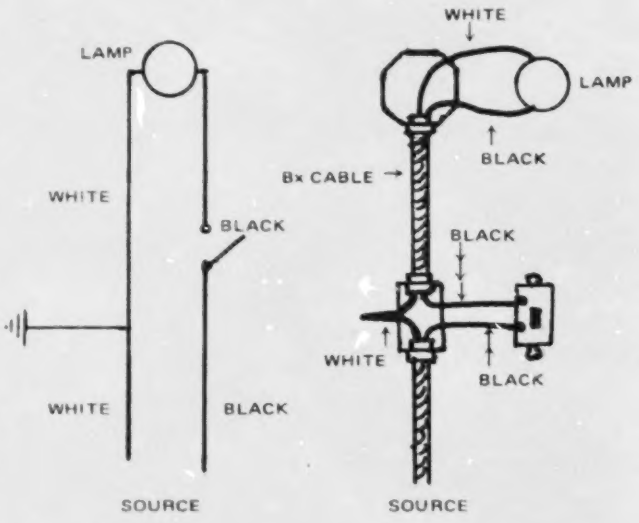
One of the most important features is that each branch circuit continues this ground in an uninterrupted fashion, direct to every 115-volt device to be operated. The grounded wire in a circuit is known as the neutral and is always white in color. This neutral *must never be interrupted* by a fuse or switch or anything else. The other wires are known as

hot. They are usually black but can be some other color – *but not white.* For electricity to flow, one black wire and one white wire must run to every 115-volt electrical device (box, etc.) along the line, *other than a switch.* Never interrupt the white with a switch.

The following information should be used in conjunction with actual classroom demonstration.

Examine a socket or a duplex outlet carefully and you will see that one of its two terminals is a natural brass color. The other terminal is a white color, usually nickel-plated or tinned (silver-looking). The white circuit wire *must always* run to a white terminal (silver-colored), and the black to the brass-colored.

Note: Switches for controlling lights never have white terminals – which means *white wires don't belong there.*



Finally, all electric cords for tools and appliances should have three-wire plugs for automatic grounding. The wall outlets themselves must be of the grounding type, with a green-colored terminal in addition to the brass and silver. Then your system is grounded from source to point of use.

If a home should be struck by lightning, grounding should prevent the unusual surge of electricity from burning wires or setting the house on fire by providing a direct path back to earth.

Accident prevention is hard to sell to the public, and insurance statistics of accidents and death record thousands of "no sales."

Electrical Symbols on Plans **Lesson 11**

Objectives:

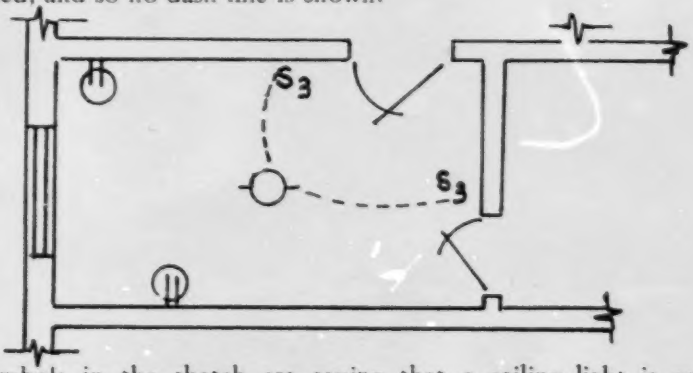
1. At the end of this lesson the student will understand why and how electrical symbols are used on plans.

2. The student will also become familiar with symbols commonly used or plans.

Related Information:

Electrical symbols represent the electrical system by means of a tiny picture language. This picture or sign language was adopted by the American Standards Association (A.S.A.) and is used by most architects, electrical engineers, and designers. (See next page for some commonly used symbols.) The electrical symbols on a blueprint are drawn simply to show the location and type of outlet, switch, or electrical device that is needed.

For example, note in the sketch below how this special language is used. Note the curved dash lines that go from the ceiling outlet to each switch. The lines are drawn curved so that they don't signify a hidden construction line. The wall outlets are not switch-operated, and so no dash line is shown.



Thus the symbols in the sketch are saying that a ceiling light is controlled by two three-way switches located near door openings. It also shows two wall outlets that are separate and do not depend on the switches.

Electrical Symbols Commonly Used on Blueprints

GENERAL OUTLETS

Ceiling Wall

- Outlet.
- Blanked Outlet.
- Drop Cord.
- Electrical Outlet; for use only when circle used alone might be confused with columns, plumbing symbols, etc.
- Fan Outlet.
- Junction Box.
- Lamp Holder.
- Lamp Holder with Pull Switch.
- Pull Switch.
- Outlet for Vapor Discharge Lamp.
- Exit Light Outlet.
- Clock Outlet. (Specify Voltage.)

CONVENIENCE OUTLETS

- Duplex Convenience Outlet.
- Convenience Outlet other than Duplex. 1=Single, 3=Triplex, etc.
- Weatherproof Convenience Outlet.
- Range Outlet.
- Switch and Convenience Outlet.
- Radio and Convenience Outlet.
- Special Purpose Outlet. (Des. in Spec.)
- Floor Outlet.

SWITCH OUTLETS

- S — Single Pole Switch.
- S_2 — Double Pole Switch.
- S_3 — Three-Way Switch.
- S_4 — Four-Way Switch.
- S_D — Automatic Door Switch.
- S_E — Electrolier Switch.
- S_K — Key Operated Switch.
- S_P — Switch and Pilot Lamp.
- S_{CB} — Circuit Breaker.
- S_{WCB} — Weatherproof Circuit Breaker.
- S_{MC} — Momentary Contact Switch.
- S_{RC} — Remote Control Switch.
- S_{WP} — Weatherproof Switch.
- S_F — Fused Switch.
- S_{WF} — Weatherproof Fused Switch.

SPECIAL OUTLETS

$O_{a,b,c,etc}$
$\ominus_{a,b,c,etc}$
$S_{a,b,c,etc}$

Any Standard Symbol as given above with the addition of a lower case subscript letter may be used to designate some special variation of Standard Equipment of particular interest in a specific set of Architectural Plans. When used, they must be listed in the Key of Symbols on each drawing and if necessary further described in the specifications.

Courtesy of American Standards Association of New York, N.Y.

PANELS, CIRCUITS, AND MISCELLANEOUS

- Lighting Panel.
- Power Panel.
- Branch Circuit; Concealed in Ceiling or Wall.
- Branch Circuit; Concealed in Floor.
- Branch Circuit; Exposed.
- Home Run to Panel Board. Indicate number of Circuits by number of arrows.
  Note: Any circuit without further designation indicates a two-wire circuit. For a greater number of wires indicate as follows —//— (3 wires) —///— (4 wires), etc.
- Feeders. Note: Use heavy lines and designate by number corresponding to listing in Feeder Schedule.
- Underfloor Duct and Junction Box. Triple System. For double or single systems, eliminate 1 or 2 lines. This symbol equally adaptable to auxiliary system layouts.
- Generator.
- Motor.
- Instrument.
- Power Transformer. (Or draw to scale.)
- Controller.
- Isolating Switch.

AUXILIARY SYSTEMS

- Push Button.
- Buzzer.
- Bell.
- Annunciator.
- Outside Telephone.
- Interconnecting Telephone.
- Telephone Switchboard.
- Bell Ringing Transformer.
- D — Electric Door Opener.
- F — Fire Alarm Bell.
- F — Fire Alarm Station.
- City Fire Alarm Station.
- FA — Fire Alarm Central Station.
- FS — Automatic Fire Alarm Device.
- W — Watchman's Station.
- W — Watchman's Central Station.
- H — Horn.
- N — Nurse's Signal Plug.
- M — Maid's Signal Plug.
- R — Radio Outlet.
- SC — Signal Central Station.
- Interconnection Box.
- Battery.
- Auxiliary System Circuits.
  Note: Any line without further designation indicates a 2-Wire System. For a greater number of wires designate with numerals in manner similar to —·—·—12-No. 18W-¾" C., or designate by number corresponding to listing in Schedule.
- $\square_{a,b,c}$ Special Auxiliary Outlets. Subscript letters refer to notes on plans or detailed description in specs.

UNIT IX – PAINTS

History of Paint **Lesson 1**

Objective:

At the end of this lesson the student will know the essential parts of a paint.

The use of paint was actually the discovery of a science teacher during one of his summer vacations. It was a pure accident, because he was actually trying to find a cave to hide from his wife and school-age kids. In any event, history owes this man a great debt for his discovery and theories. All lessons on the history of paint, taught in all schools, are based on his findings. The following lesson on the origin of paint has been taken directly from a brown lunch bag he used as a notebook.

The first paint job was actually traced by paint drippings leading into a cave. About 10,000 years ago, certain cave persons painted colored pictures on the walls. Some cave walls were painted to cover up wall cracks and defects, just to get the landlord higher rents. Other paint jobs were just to kill time. Probably some hungry lion or rhino was blocking the cave entrance, and the occupants painted pictures until it went away.

At any rate, these early cave decorators made their paints with coloring matter called pigments. The pigments probably kept falling off the cave walls, and so they added a sticky binder. Finding a good binder was really a sticky job. The first binder was a grease or oil taken from the mean vicious animals that blocked the caves. To get this binder the early chemists had to be extremely careful that the animals were dead before they started to collect grease. Grease-grabbing and oil-collecting from live animals resulted in some cave walls' being decorated with cavemen. (This was not a pretty picture).

Most of the cave painters were non-union, and so they left no records as regards price per hour or per cave. Oh, well – let's get on with the serious stuff (lesson).

Early pigments were made mostly from minerals called ochers. Ochers are minerals made of iron and ogygen as found in nature. The ochers produced nice earthy colors, like reds, yellow, orange, and browns. Early painters also discovered that burning bones gives a black pigment. (Imagine that! These cave snappers didn't waste a thing on the animals – they ate the meat, collected the grease, and burnt the bones to make paint. Today's meat is mostly bones, and so it might pay to make our own paint or sell the bones to paint stores.)

Today's paints contain two essential parts. The first part is made from colored clay or rock, finely ground, called *pigment*. The second part is a liquid binder, usually water or oil, called the *vehicle*. The liquid vehicle holds the pigment together on the surface and makes it easy to apply. The vehicle in the modern type of oil paint is linseed oil, tung oil, or some other so-called drying oil, sometimes combined with synthetic (man-made) materials. A third type of ingredient added to oil paints is a *drier*. The drier speeds up the oxidation and makes the paint dry faster. This drying factor is very important when painting toilet seats, so remember the word "drier."

Oil paints sometimes need to be thinned so that they can be more easily applied. Turpentine, which comes from pine trees, is usually used with good results. Remember to *always read the label, because different paints require different thinners.*

Paint is mighty important because it is used to protect and beautify everything in this world except food and clothing. Folks even use paint to beautify themselves.

Activity:

Your instructor will use some exterior oil-based paint to paint several boards.

1. Put a tiny quantity of paint into two cans. Use water as a thinner in one and oil in the other. Students will observe and take notes.
2. Read label. Do you understand all the big words? Ask questions.
3. Paint boards and let dry for several days. Why does it take so long to dry?

Purpose of Paint **Lesson 2**

Objective:

At the end of this lesson the student will understand the three main functions of paint.

Related Information:

First let's review a little more history (as it never was).

The Early Beginnings of House Painting

In the heyday of the log cabin, as long as the bark stayed on, there was no need for paint.

Then suddenly log exteriors took a sudden turn for the worse. Hostile Indians started shooting arrows, throwing spears, and kicking up huge quantities of dust. This was all very destructive to bark. Then there were hostile birds and insects that started snapping off the bark and the bark became worse than their bites. The housing developments started to look shabby. The logs started to crack, split, rot, and grow fungus – it was truly a bad scene. Thus, a group of concerned homeowners got together to discuss the bark blight. After a great deal of heated discussion and violence they decided to strip the bark that was left and paint the logs.

A pack of the boys went down to a used pony lot to see Quick-Buck, a local Indian wheeler-dealer. If anybody had paint, Quick-Buck would have it, because Indians used it in all their fights. As luck would have it, Quick-Buck had a few drums of surplus war paint that was yellow and a poor seller amongst the braves. He then gave them a price they couldn't refuse, threw in two pounds of turkey feathers, and unloaded the whole lot. And that's how wood got its first coat of protection.

Now let's get down to some facts (true). House paints serve three major functions: protection, insulation, and beauty.

1. **Protection.** Paint products protect against sun, rain, snow, sleet, dew, fog, dust, and – believe it or not – insects. It also protects against air pollution, corrosion, and rust. In the case of wood it protects against checking, cracks, rotting, warping, and discoloration. Even the interiors of homes are protected from dirt, grease, grime, household chemicals, and abrasives in daily use.

2. **Insulation.** Paint also is an excellent medium of heat-reflection through use of color. Light colors reflect a great deal of heat away from the house. If you have ever owned a black hearse or have ridden in the back of one, you would realize how dark colors absorb heat.

3. **Beauty.** Paint restores the original appearance of a house and in some cases improves it. Beauty not only brings satisfaction to the owner but also increases the property value.

Composition of Paint **Lesson 3**

Objective:

At the end of this lesson the student will understand the recipe for making paint.

Related Information:

Folks called students don't have to be paint chemists, but they should be familiar with the ingredients and what they do. For example, what type of paint should you use on a seat, and how long does it take to dry?

Well, most paints consist of four types of materials: a pigment, vehicle, thinner, and drier.

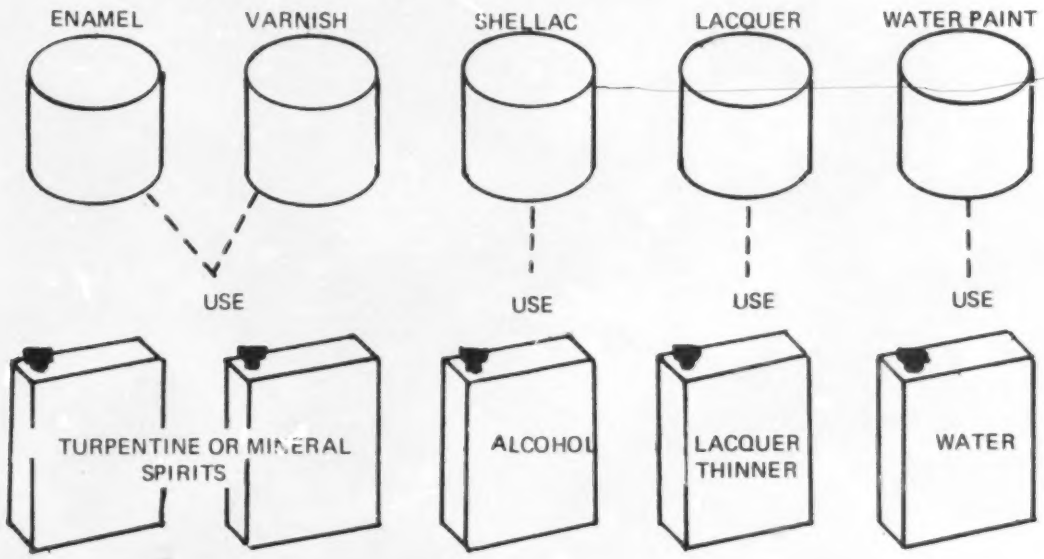
1. **Pigment.** Pigment is a finely ground solid that provides hiding power plus a color to paint. The finely ground solids are derived from animal, vegetable, mineral, or synthetic materials. A large percentage come from mineral oxides such as lead, titanium, zinc, and certain clays that contain iron.

   Paint pigments are often combined with extender pigments that do not add hiding power but are added to increase bulk or improve the product. In most cases, extenders prevent checking, cracking, or excessive chalking, or they keep the primary pigment from settling into a hard mass.

2. **Vehicle.** The vehicle acts as a binder, that is, it holds the fine particles together so that they can be spread. Imagine trying to spread the finely ground solids without some liquid-type base. The liquid must be able to stick to a surface, penetrate the pores, and dry into a tough, protective film. Oils such as linseed, tuna, soy, or castor are used for oil paints; synthetic gums or resins for alkyd paints; emulsions of synthetic resins and water for latex paints.

3. **Thinner or solvent.** For oil or alkyd paints, turpentine or mineral spirits are used. The thinner or solvent makes the paint spread more easily and penetrate the surface. Once it has done this job, it evaporates, leaving a coating of oil and pigment. Latex or acrylic emulsion paints use water as a solvent, but this is used more for spreading than penetrating.

4. **Drier.** The drier helps speed up the drying process by combining with oxygen rapidly. Driers consist of the salts of certain metals, such as cobalt, lead, manganese, calcium, zinc, or iron.



Proper thinners for paint products

UNIT IX – PAINTS

Exterior Paints **Lesson 4**

Objectives:

1. At the end of this lesson the student will understand the three basic elements essential to good exterior painting.

2. The student will also understand the relative advantages and disadvantages of the two most popular types of exterior paints.

Related Information:

The cellular and porous nature of wood is an invitation to moisture, oxygen, and carbon dioxide, upon which mildew and other fungi can grow. Unless these pores are sealed, wood will decay, split, check, or warp; thus the need for paint is obvious.

A successful paint job consists of three basic elements. First of all, proper *surface preparation.* Secondly, there must be a *strong bond* between the surface and the paint. Thirdly, *good quality materials* are needed to provide a good paint film.

Preparation of new wood consists of removing all grease, dirt, pitch, or foreign matter. Knots should be sealed with shellac, aluminum paint, or prepared knot sealers. Wood resins should be scraped and sanded, and any lime or cement removed.

A strong bond requires that the new wood receive a prime coat of paint. A primer consists of an exterior paint that has *controlled penetration.* The purpose of a primer is to seal the porous wood uniformly and provide a roughness or *tooth* for succeeding coats to grip to. Even absorption and sealing plus "tooth" can provide the strong bond that makes for a successful paint job.

The finish coat should be labeled house paint. This is the paint best suited for wood. Exterior house paints are most commonly formulated as either oil-base paints or latex paints. Both have advantages and disadvantages.

The advantages of oil-base paints for exterior work:

1. Oil-base paints, especially white, have controlled chalking. White oil-paint stays white longer than latex paint.

2. They cover better and leave a heavier film.

3. They cover more area than latex because they are more pliable, drip more slowly, and have greater hiding power.

4. Penetration into wood is greater than with latex; hence they protect better.

The advantages of latex-type paints are:

1. Colors are more stable and long lasting, especially white – does not turn yellow as easy.

2. They are easier to apply and clean up.

3. They are non-toxic and have little odor.

4. They are moisture- and alkali-resistant.

5. The costs of labor and material are slightly lower.

6. They are fast drying and can be recoated faster.

7. They are less affected by moisture and dampness; painting does not depend on ideal weather and a perfectly dry surface.

8. The finish is softer and permits wood to "breathe"; and hence is more resistant to damage from moisture pushing through from inside.

UNIT IX – PAINTING

Interior Paints **Lesson 5**

Objectives:

1. At the end of this lesson the student will know the basic types of interior paints and how they are used.

2. The student will also learn the advantages and disadvantages of some of these paint products.

Related Information:

There are various types of interior paints; selection depends on the specific area where they are to be used. These interior paints can be divided into three main categories: oil-base paints, alkyds, and latex.

1. Oil-base. Interior oil-base paints have been largely replaced by synthetics. However, they are still available and worthy of consideration. They fall into four major groups, as follows:

   a. **Gloss or Semi-gloss.** These paints are used chiefly in kitchens or bathrooms, rooms most subject to oil, grease, soap scum, and sticky films. They provide a hard, glossy surface that is resistant to penetration and hence easy to clean. These paints wash easily with soap or other alkaline cleaners.

   b. **Flat oil paints.** These have excellent covering power and a fairly even penetration. Although harder to apply than the synthetics, they can cover spackled areas without being sucked in and creating flat-looking spots.

   c. **Enamel.** Enamel has a varnish vehicle and dries with a hard finish that resists abrasion, corrosion, water, and discoloration. The finish is available in gloss, semi-gloss, and flat, and can be easily washed with soap and water.

   d. **Primer-Sealers.** These are especially formulated to provide a strong bond, "tooth," and sealer to protect finish coats from surface defects.

2. **Alkyd.** Alkyd paints are made from resins made by combining alcohol and acid. These hard resins, in combination with oils, produce a hard, tough surface. They are formulated to produce gloss, semi-gloss, and flat paints. Alkyd paints are flexible and water- and abrasion-resistant; they wash easily and have good color-retention. Alkyds have definite advantages over interior oil paints as they are tougher, easier to apply, resist scrubbing, and have much less odor.

3. **Latex paints.** Latex-base paints are emulsions of a synthetic resin and water. The original latex paints used an artificial rubber, but today they use various synthetic resins and are still called latex. Latex paints have many advantages. They are . . .

   a. Water-soluble, hence easy to clean up
   b. Very easy to apply by brush or roller
   c. Quick-drying
   d. Non-toxic, with little odor
   e. Resistant to water and alkali
   f. Washable
   g. Durable and self-sealing
   h. Non-flammable
   i. Highly fade-proof
   j. Porous, so that the paint film does not trap moisture

UNIT X – WALL AND FLOOR COVERINGS

Ceramic Tile – Purposes and Uses **Lesson 1**

Objectives:

At the end of this lesson the student will understand the purpose of ceramic tile and its uses in the home.

Related Information:

As luck would have it, a science class was on a field trip one day and found some spiral notebooks in old tombs that had pages made of tile. The cover page was dated 4000 B.C.

For thousands of years tile-making languished – until bathtubs were moved indoors. Grown persons did not bathe too often, and when they did they weren't splashers – but kids kicked up a storm in the bathroom. They went wild in the tubs and splashed water all over the wallpaper and rugs.

That's when people became foxy and decided to protect their homes. They took certain types of earth that contained clay and started baking tiles in the sun. The manufacturing progress was slow until someone thought to put the tiles in pizza ovens and used artifical heat. This started the whole industry of ceramic tiling.

True facts. Ceramic tile actually dates back to some 4000 years B.C. Excavations have revealed tiles formed from various types of earth and sun-dried. Through the years the product was gradually improved by baking with artifical heat. Finally, people discovered that certain materials when heated would melt and form a hard, shiny glaze. Tiles were used throughout the centuries for decorative as well as practical purposes. Gradual improvements in materials, color, and techniques have been made, and today we produce a wide range of ceramic building materials.

1. **Purpose.** The primary purpose of ceramic tile is to provide a sanitary, waterproof surface, resistant to moisture, soap, and cleansers. The hard, glazed tile provides this long-lasting wall and floor covering.

2. Uses. Ceramic tile in home construction is used primarily in bathrooms and kitchens. The material can be used for walls, floors, ceilings, and counter tops. In stall showers it may be used for ceilings as well as floors and walls. In recent years it has even been used to construct built-in bath tubs.

   Some kitchen counter tops and back splashes are being constructed completely of tile. In other situations, tile is used as a back splash where the counter top ends.

UNIT X – WALL AND FLOOR COVERINGS

Types of Ceramic Tile **Lesson 2**

Objectives:

1. At the end of this lesson the student will know about the two general types of ceramic tile and their use.

2. The student will also know of the other types of tile available for home use.

Related Information:

Ceramic tile is a great boon to the homemaker because its nonporous surface is so easy to keep clean. There are two general types of ceramic tile. In home construction the most widely used are the 4¼"x 4¼" tiles, which are used on walls, ceilings, and counter backsplashes. However, tiles also come in a variety of other sizes and different shapes. So-called mosaic tiles come in tiny or large pieces and are sold in one-foot and two-foot squares. They come in a variety of irregular, round, square, or rectangular pieces pasted to a paper backing. The paper backing is used to space them and permits installation in fairly large sections.

Ceramic tile comes in three textures.

(A) High-glazed tiles have a hard, glossy, nonporous surface, which is very easy to keep clean and sanitary.
These tiles are used primarily for walls, countertops, and backsplashes in kitchens and bathrooms. The varieties manufactured in Japan are extremely colorful and decorative. They are made in one- and two-foot squares with a cheesecloth-type of backing. Thus, they are ready-spaced and convenient and easy to install. They are rarely used for floors because the glazed surface would be hazardous and easily marred by traffic.

(B) Another texture is known as *crystal-glazed.* This has a granular or rough texture. These tiles are more or less slip-proof and are used for floors. They come in a variety of shapes and sizes; the 1" hexagon, the ¾" square, and the random pattern are most popular. They are somewhat harder to keep clean than high-glazed tiles; however, their primary purpose is safety.

(C) Matte and satin-matte tile have a hard, easy to clean surface but not much glare. They have the advantage of a sanitary surface without so much glare and reflection of light.

Thus the sizes, textures, and colors offer a wide range for decoration. Colored tile and bathroom fixtures have made the modern bathroom sanitary and cheerful.

Ceramic tile are often used unglazed for floors and walls, especially in swimming pools and gardens. Other types of tile used in and around the home are as follows:

Quarry tiles. These type of tiles are a combination of sand and clay pressed in a hydraulic press and baked hard. These tiles are extremely dense and absorb very little water. Quarry tiles are manufactured in a variety of sizes and thicknesses. The glazed quarry tiles are primarily for walls, and the unglazed for floors. Their greatest use is in commercial or public buildings; they are not used extensively in homes.

Patio tiles. Patio tiles are similar to quarry tiles but are made with a clay base instead of sand. They are used primarily for floors and patios, both indoors and outdoors.

UNIT X – WALL AND FLOOR COVERINGS

Ceramic-Tile Installation **Lesson 3**

Objectives:

At the end of this lesson the student will understand the two methods of installing ceramic tile and the advantages of each.

Related Information:

Ceramic tile can be installed in two different ways. This is the original method: The tile is attached to a cement base on the walls and on the floor. The cement base requires a rigid, fine, metal mesh applied to the open studs to act as an anchorage base. The cement plaster consists of portland cement and sand. It is applied in two coats and left to dry. While the cement plaster is drying, the tiles should be left totally submerged in water for at least 24 hours. Thus the tiles reach their saturation point and will not suck the moisture out of the adhesive cement.

Each separate tile is then cemented with a wet glob of cement, uniformly spread out. Then the tile is pressed into place. In ceiling applications the cement should be carefully buttered on all four edges, leaving the center hollow. This permits suction to assist in holding the tile up.

Note the following aids to making the tile stick: First, the tile is grooved or ridged to grip the cement. Secondly, the tile is soaked to prevent its absorbing water from the cement plaster. Finally, the edge-buttering technique provides suction when the work is overhead. This method of applying tile requires considerable skill in masonry and is costlier than the newer method, described below. Once applied, the tile is difficult to remove, and so repairs are also more costly.

Floor tile is applied the same way except that the tile is in small pieces, attached to sheets. The sheets of tile are applied with the paper side up and pressed into place. The paper is wet and removed, and a creamy cement paste is added and fills the joints.

The modern method uses an adhesive in place of cement for adhesion. The accepted practice is to install tile on a waterproof dry-wall base. However, tile can be applied to any strong hardboard or backing.

Application begins with applying a special waterproof mastic with a notched trowel. The grooves in the mastic act as a cushion for even pressure and provide a degree of suction. The mastic must be pliable, free of lumps, and uniformly spread. The modern ceramic tile has projections on the sides that provide proper spacing automatically.

Whichever method is used to set the tile, once all are in place, a white or colored grout is used to fill the joints and make them waterproof. The grout can be made from a mixture of white sand and white cement, or a prepared tile grout may be used. Excess grout is removed with a soft striking tool on the joints and a wet sponge. Once the grout is set, a damp cloth will clean off any excess.

Simple tile jobs can be done with simple tools such as glass cutter, nippers, and carborundum stone. Tiles are cut by scoring the glazed surface. Odd shapes can be cut by scoring the curve and slowly breaking off tile with nippers to the scored line. Rough edges can be smoothed with a carborundum stone.

Summary. This is what you have learned:

Glazed tile is similar to glass and can be cut the same way.

Tile is not as brittle as glass and can be shaped with plier-type nippers and abrasives.

The back side of tile is porous and provides excellent adhesion.

Adhesion can be improved by "buttering" cement on edges or grooving the mastic.

Grout is a waterproof cement filler for the joints.

Any strong, durable backing can be used for tile applied with mastic.

UNIT X – WALL AND FLOOR COVERINGS

Resilient Floor Coverings **Lesson 4**

Objectives:

1. At the end of this lesson the student will be aware of some of the most popular floor coverings available.

2. The student will also understand that actual selection of material requires additional research into function, traffic conditions, comparative costs, and maintenance.

Related Information:

"Resilient" floor coverings have a certain amount of "give" to them – they are easier on the feet than wood floors, although not as easy as carpeting, of course. The following description and classification of resilient floor coverings is general in nature. Actual real-life choices should be based on a more detailed source. Refer to books on architecture, building products or consumer guide books – *Don't* rely on advertisements or manufacturers' claims.

(A) **Asphalt Tile.** Asphalt tiles are composed of asbestos fibers bound together by a blend of asphaltic binders. They are manufactured in 1/8" and 3/16" thicknesses and in a variety of colors and designs. They are the least expensive of the floor coverings, are highly durable, and can be used over wood or concrete subfloors. They are most widely used in basements, recreation rooms, and in homes of slab construction. They are very brittle and tend to crack if placed on uneven surfaces. The tiles are highly resistant to water, but are not resistant to acids or petroleum solvents such as kerosene, gasoline, or any oil-based product.

(B) **Vinyl-Asbestos** tiles are made of a composition vinyl resin and plasticing agent, plus asbestos fibers, pigments, and fillers. Vinyl asbestos is superior to ordinary asbestos or pure vinyl tile in many ways. It is not as brittle as pure asbestos and in addition is highly resistant to fats, oils, most acids, alkalies, and petroleum solvents. It is superior to pure vinyl in that it will not dent, mark or mar as easily.

(C) **Vinyl Tile** is made of a layer of vinyl plastic bonded to a flexible backing material. Vinyl tile is flexible and resists cracking, and is highly resistant to fats, oils, most acids, and petroleum solvents. The disadvantages are its high costs as compared to asbestos or vinyl asbestos and its lower resistance to denting and scarring. Furniture, especially chair legs, leave noticeable dents. In addition, women's high heels or spikes can dent or damage its surface.

(D) **Linoleum.** This material is a composition of specially treated linseed oil, powdered cork, resin, wood flour, and color pigments spread over a cardboard backing and rolled into sheets. Linoleum is available in either small tiles or large rolls or sheets. Large sheets minimize joints and provide an easier-to-clean surface than separate tiles. Linoleum in large sheets is more expensive than asbestos or vinyl asbestos tile but is more durable, with less chance of popping or coming loose. However, it requires more skill to install and is more difficult to repair.

Note – Linoleum "rug" is a roll-type or sheet linoleum that is surface-finished only. It should not be confused with true linoleum, whose quality is consistent throughout its thickness. Linoleum rug is a low-cost substitute, for short-term use only.

(E) **Cork.** Cork tile is made by mixing cork shavings with resins, compressing the plastic mixture in molds, and then baking. The tiles are used above grade; they are not recommended for concrete. Cork tiles are warm, quiet, and resilient, but not as durable as other floor coverings. They resist water but are not resistant to oils, fats, or grease. They would not be recommended for use in kitchens, dinettes, or bathrooms.

(F) **Rubber Tile.** Rubber tiles are usually made from synthetic rubber because natural rubber would dry out and crack too easily. Plastic binders and pigments are mixed with the liquid rubber, rolled and pressed into sheets, then cut up into tiles. Rubber tile is recommended for use above the ground level. The advantages of rubber tile are pliability, resilience, and good sound absorption.

UNIT X – WALL AND FLOOR COVERINGS

Wall Coverings **Lesson 5**

Objectives:

At the end of this lesson the student will have a knowledge of the various types of wallboards most commonly used in residential construction.

Related Information:

The materials which are used to finish interior walls include wood boards, wood paneling, ceramic tile, paper, fiberboard, glass, plastics, and paint. This lesson is primarly concerned with wood paneling and fiberboard.

(A) **Wood paneling** is available in a variety of thicknesses, widths, and lengths. However, the most popular size is 4'x8'x¼". These panels are available in natural or prefinished surfaces and are applied with matching nails or an adhesive paste, or a combination of both.

Wood paneling is also made by reproducing a wood finish by a photographic process and then applying a plastic (vinyl) coating. Reproductions can imitate almost every shade, tone, and grain of wood. These panels are inexpensive, but are not as durable as true-wood panels, because the surface beauty is only skin deep. Repairs or refinishing are almost impossible.

Panel thickness is extremely important, and this is where the buyer or builder must be wise.

Normally panels that are less than ¼" present a nailing problem, because the holding power of countersunk nails is greatly reduced. In extremely thin paneling, the enlarged head of brad or finish nail practically passes through all layers when countersunk. Thus special head-type nails must be used, and an adhesive is advisable. Also, thin paneling follows every defect and contour of the wall and fails to give a leveling, flat appearance.

Full-thickness panels are more rigid, offer a better nailing surface, and are less likely to twist, buckle, or pop loose.

(B) **Wood Paneling (Boards).** This paneling consists of separate boards that have a wood tongue on one edge and a groove on the opposite edge. Thus when they are fitted and nailed together they form a single continuous-appearing surface. The boards are usually ¾" thick and come in 4", 6", 8", and 12" widths and random lengths. The finished face surface can give a V-joint appearance or a fluted pattern. Panels are available in such woods as knotty pine, pecky cypress, oak, chestnut, cedar, pecan, and other more exotic varieties of wood.

This type of paneling is costlier than plywood but has a special beauty that some people prefer. The advantages are strength, beauty, and ability to be repaired or refinished if damaged.

(C) **Hardboard** consists of pulverized wood that has been reduced to pulp, the moisture removed, and a variety of binders added to form a plastic mix. This mixture is pressed and baked. Panels are usually 4′ x7′ or 4′ x8′, ¼″ thick.

One treatment consists of printing a wood-grain pattern on the face and cutting irregularly spaced V-grooves to represent random planks. Other hardboards have a deep leather grain embossed.

Another type of treatment consists of covering the hardboard with a plastic film printed in a wide variety of wood, stone, or fabric patterns with a baked-on top plastic coating. Boards may also be left plain, marbelized, or formed into 4″ squares with a baked-on enamel coating. They are frequently used in kitchens, bathrooms, and in other areas as a tile substitute. In some cases where a continuous, seamless surface is desirable, they are actually superior to tile. The finishes resist acids, oils, and grease, and hence are easy to clean.

UNIT XI – SHEET METAL

Exterior Uses **Lesson 1**

Objectives:

1. At the end of this lesson the student will understand the importance of not combining dissimilar metals in outdoor work.

2. The student will know about some of the uses of sheet metal in exterior work, and which metals are used most for each purpose.

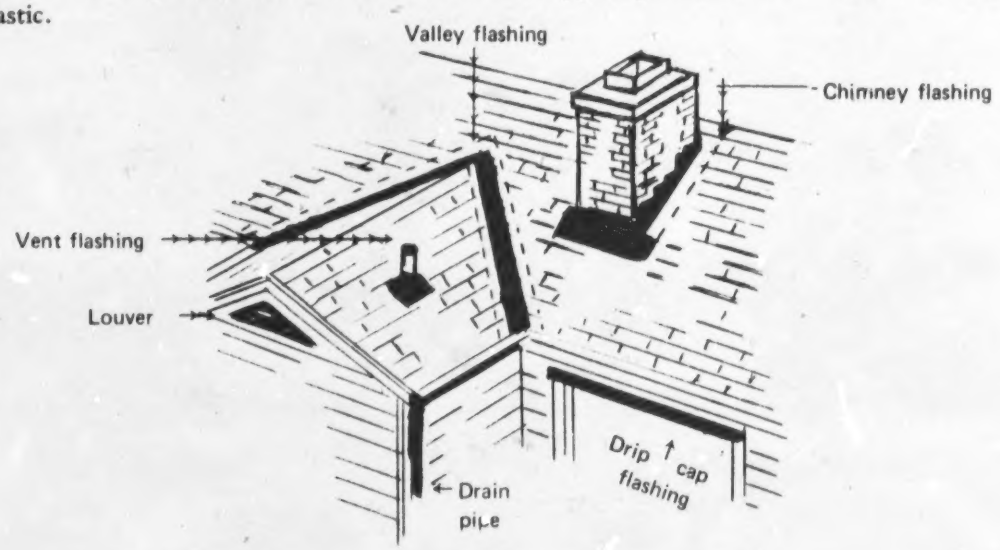
Related Information:

No builder in his right mind would install copper flashing with galvanized nails, or, for that matter, use any two dissimilar metals together in exterior work. He knows that one or the other metal, or both, will deteriorate.

Two different metals used together produce a *chemical reaction* when wet. The reason is that the metals and the water form a kind of battery and produce a tiny electric current. In this process at least one of the metals will be gradually destroyed.

The following are the most important uses for sheet metal in exterior work.

Flashing. Flashing is a metal stripping which covers the joints and seams on a house – for example, the junction lines between the chimney and roof, housewall and roof, and others. Flashings may be made of aluminum, copper, galvanized sheet metal, or even plastic.



FLASHINGS AND OTHER EXTERIOR USES OF SHEET METAL

For the flashing to work correctly, the roofing material must overlap it, so that rain water will simply run off it. This prevents water from coming in from above. The overlap should be large to prevent leaks caused by upsweeps of water pushed by wind pressure. (In case you didn't know it, water loves to sneak into houses pushed by swirling wind currents or pulled by capillary action.)

You remember that capillary action is a drawing *up* of water through tiny tubes or other very narrow passageways.

Flashing around a chimney is flexible enough to permit settling of the structure without breaking. On valleys of roofs it acts like a gutter, projecting far enough on both slopes to prevent water entry.

Flashings of all types may be damaged by corrosive gases, fumes, and acids in the atmosphere. They should be periodically inspected for breaks or corrosion. A "leaky roof" is very likely to turn out to be a leak through, under, or around some flashing.

Small strips of flashing, usually of aluminum, are used over the tops of doors, windows, and other openings. They extend over the top of the frame and form a water-tight seal between the frame and the house walls. These are called drip-caps.

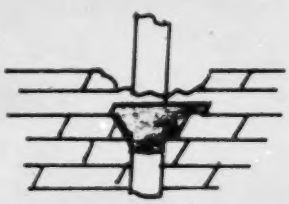
Aluminum in rolls is used to form a termite shield on the outside walls, between the blocks and the sill. It is usually formed on the job so that it covers the top of the wall and projects several inches down on each side of the wall.

Louvers. Louvers are finned or slatted openings for ventilation on the sidewalls. Aluminum louvers in round, rectangular, and triangular shapes provide maximum ventilation using the least amount of material. They also have the advantages of being non-staining and are inexpensive to buy and install.

GABLE LOUVER

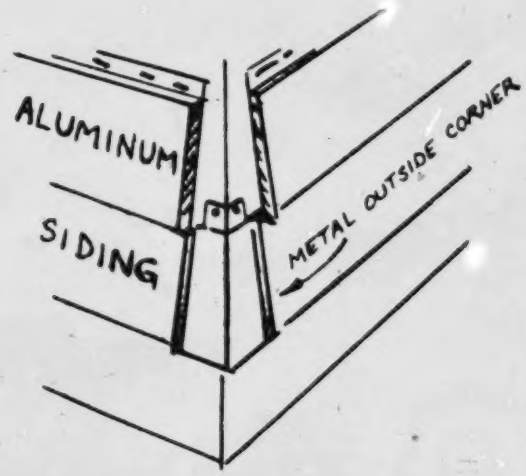
Vents. A variety of sidewall and roof vents are available for exhausting fumes, heat, and odors. They are designed to provide exhaust yet keep out the rain.

Vents for the stacks of drainage systems are a "special breed of cat" and need a copper or sheet-lead flashing to prevent leaks. Most generally they come as a preformed cap that slides over the vent pipe. They must be installed so that water flowing down the roof flows on to the flashing and back on to the roof – not down the stack.



VENT FLASHING

Metal gutters will be discussed in detail in the next lesson. You should realize, though, that there are many other exterior uses of sheet metal around a house. The illustration below shows one of them.



Gutters and Accessories **Lesson 2**

Objectives:

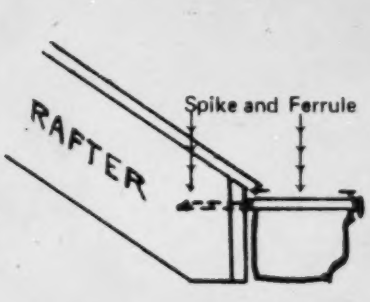
1. At the end of this lesson the student will know about the various types of rain-carrying equipment available.

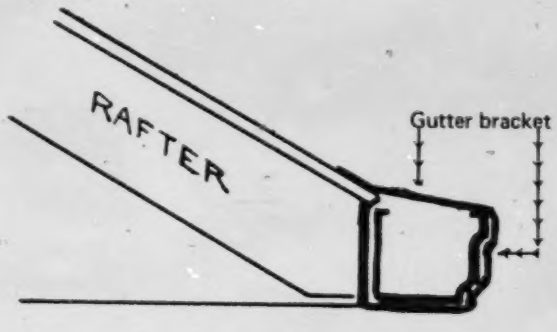
2. The student will also learn the advantages and disadvantages of some materials.

Related Information:

Sheet metal was one of the earliest materials to be used for gutters and leaders. A galvanized sheet metal, heavily tinned, is still being used. It has the disadvantages of rusting and staining, however, and so aluminum has largely replaced steel in modern construction.

Aluminum gutters come either with a baked-on enamel finish or in a natural finish. The baked-on finish is better looking and more popular. The gutters can be purchased in long lengths, minimizing joints, or they can be made in one piece right on the job. Some contractors have a truck that is capable of preforming rolled aluminum stock into continuous lengths of gutter. For example, a 60-foot length of gutter can be produced in one piece with anenamel finish. Preformed fixtures to fit the shape of the gutter are used as hangers, or a long spike with a ferrule may be used.





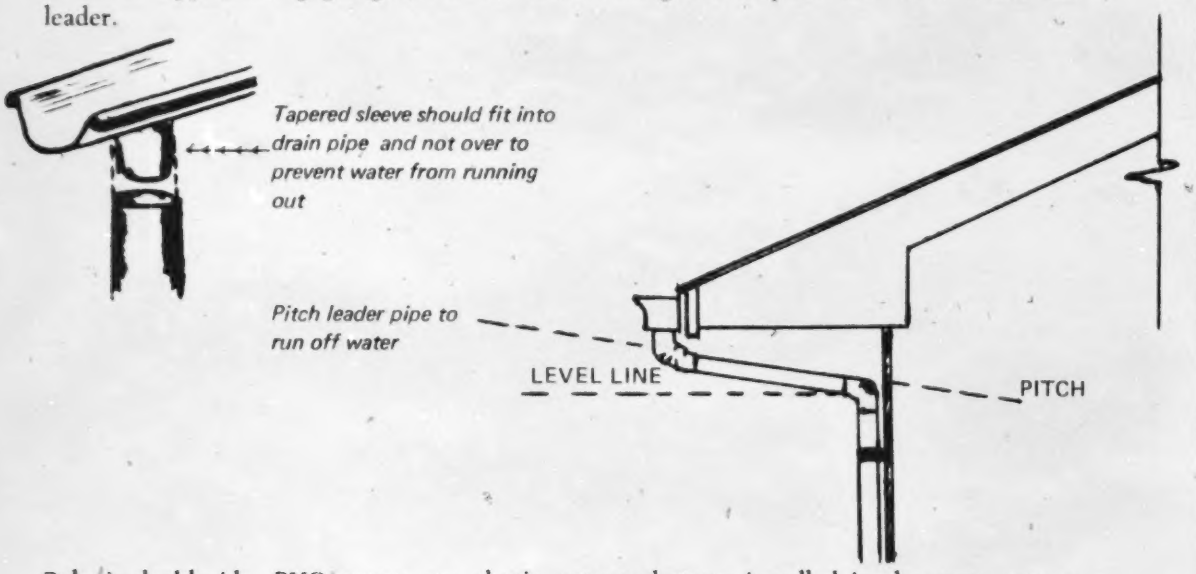
Two pieces of gutter can be joined either by lapping the joints where they intersect or by using a preformed joint. Lapping one section of gutter over another, using an aluminum liquid solder and rivets, works well for lengths under 50′. Lengths that exceed 50′ are more subject to the stresses and strains of expansion and contraction. Thus a preformed joint in the shape of the gutter is used; it provides a built-in expansion feature. The center of the preformed unit has a neoprene (rubber) strip that acts like an accordion and provides room for expansion and contraction.

Many of the fittings such as corners, downspouts, and end caps, come preformed and can be secured with aluminum liquid solder, or rivets, or both.

A gutter must be installed with the proper pitch to the outlet end or ends. Normally, a pitch of ¼" on the outlet end is sufficient, because water will flow rapidly enough if there is reasonable pitch. Too much pitch, on the other hand, causes the water to rush down to the outlet faster than it can flow out, and thus can cause overflowing.

Never assume that your roof line is level, because frequently it is not. Establish a true level line, using a level, chalkline, and ruler. Once the gutter is in place, test it with a pail of water or a hose to see if you have pitch and if the rate of flow is good.

The leader or run-off pipe must also provide the proper pitch if offset. As a rule, ½" to the foot provides a rapid discharge of run-off water. Fittings should always be installed with the upper fitting going inside the lower fitting, to keep all the water inside the leader.


Tapered sleeve should fit into drain pipe and not over to prevent water from running out
Pitch leader pipe to run off water
LEVEL LINE
PITCH

Polyvinyl chloride. PVC gutters are plastic gutters that are installed in the same way as aluminum. However, they still lack popularity because of two drawbacks. They have a great expansion rate and hence have a tendency to buckle in tight quarters under high temperature. They also are less rigid and present a problem when ladders are placed against them.

Gutter screens and covers of various types are available. They are fastened to the top of the gutter for the purpose of keeping out leaves, twigs, nuts, rubber balls, and unidentified flying objects. They have their plusses and their minuses, however, and many people prefer to periodically check and clean out the open gutters instead. Since some junk does get through gutter screens anyway, some cleaning will still be needed. And once the gutter screen is in place, cleaning becomes a major operation instead of a minor nuisance.

UNIT XI – SHEET METAL

Interior Uses **Lesson 3**

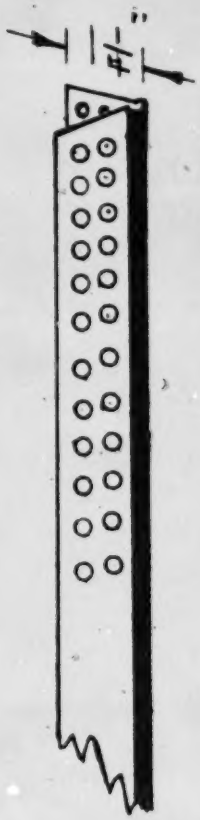
Objective:

At the end of this lesson the student will know about additional uses of various types of sheet metal in home construction.

Related Information:

Sheet metal has many uses in the interiors of homes during construction.

Metal corners. Most homes, whether they are finished with plaster or plasterboard (sheetrock), use preformed metal corners for the interior walls. They are made of alloys of tin or zinc to resist rust and are used to reinforce and provide straight, smooth corners. They are also made in a wide range of preformed arches, primarily for plaster, but some can be used with wallboard. (Note the perforations in the illustration. These serve two purposes: they provide for nailing and also act as keys for the sheetrock spackling paste.)



Performed metal corner for sheetrock (dry wall) construction

Wire lath. This is a preformed wire mesh, most commonly in 24" x 96" size. These mesh sheets are nailed across open framing or rock-lath-covered walls and are used as a base for plaster. Wire mesh provides strength and rigidity but has enough flexibility to compensate for settlement. It is especially useful in corners and joints, as a reinforcement to resist cracking.

Galvanized sheet metal. This metal is widely used for heating and air-conditioning ducts, pipes, and fittings. It is also used as flue pipe for heaters, furnaces, and appliances. Galvanized pipe is used for fan ventilation and other exhaust systems.

Aluminum sheet metal. Sheets of aluminum come in various gages and widths; it may be used in place of galvanized metal for some interior uses. Aluminum is sometimes used to form the ducting pipes and fittings for forced hot-air systems and to repair them. Some contractors still use it to enclose cold-air returns between the joists rather than build ducts.

Sheet lead. Lead in a rolled-sheet form is used frequently to form a waterproof base for stall showers. Once the stall shower is framed, sheet lead is placed along the bottom, with the sheet folded and continued up the walls. Thus it forms a huge lead pan about 12" deep. A sheet-lead base permits a wide range of custom-built shower stalls. The base then receives a bed of cement and ceramic tile plus a floor drain. Where size and shape of the stall are standard, however, preformed terrazzo bases are usually used.

Prefabricated Products **Lesson 4**

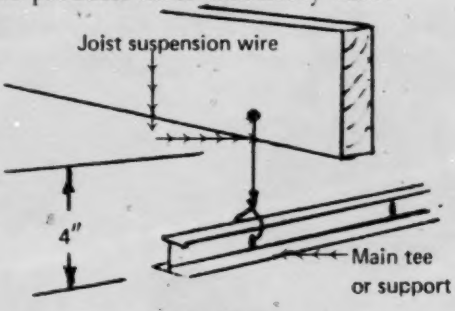
Objectives:

At the end of this lesson the student will know about the various prefabricated metal products in a home and how they are used.

Related Information:

Sheet metal has been prefabricated into many useful products to be used in construction or to be added on. The following is a partial list of the products most commonly used.

Gridwork. Sheet metal strips in the form of angles and tees are frequently used to install suspended ceilings. The gridwork usually consists of a sheet-metal angle strip around the walls. Then a network of T-shaped runners is installed on wires, and you have a metal framework to hold up ceiling panels. The panels vary in texture and design, and some are omitted for lighting panels.



The ceiling is thus suspended from the joists and in a sense just floating. This type of ceiling is ideal for access in case of repairs and is also readily adaptable for additional lighting.

Laundry chutes. These chutes are prefabricated out of metal and are intended for in-the-wall or through-the-floor installation. Some units come complete with a pre-finished metallic hamper housing.

Fire doors. Doors leading from an attached garage have a sheet-metal facing or covering. They are intended to act as a fire stop in the event of a fire in the garage. A garage, after all, houses a car that uses gasoline. Gas spillage and a possible short in the electric lines are fire hazards. The galvanized sheet metal acts to retard the fire and confine it. Some sheet-metal-covered doors are factory made, others have the covering installed on the job site.

Awnings. Prefabricated aluminum awnings in a variety of colors and designs are available for windows, doors, porches, canopies, and carports. They are extremely light in weight and sturdy and hence need no heavy understructure. For this reason, as well as their resistance to fire, they are readily accepted by most building codes.

Aluminum doors and windows. These two products have solved one of the toughest chores for a homeowner. Previously, heavy wooden storm windows and screens were constantly being interchanged. This involved much labor, painting, and the risk of accidents from ladders. Today such windows are permanent and are self storing. Unfortunately, you still have to clean them.

UNIT XII – VENTILATION

Purposes of Ventilation **Lesson 1**

Objectives:

1. At the end of this lesson the student will know how ventilation affects health, comfort, and the condition of the structure.

2. The student will also understand how insulation and modern airtight construction make ventilation even more critical.

Related Information:

Ventilation refers to the circulation of air that expels moisture, heat, and pollutants and supplies fresh air. Truly this is one of the most important features in a house, and yet it is sadly neglected.

It is amazing how many homeowners, builders, and even building codes neglect this critical factor. This ignorance prevails despite the easy access to education, printed government guidelines, and tons of free literature by manufacturers. But *you* don't have to be ignorant. Read on.

One reason that indoor ventilation has become increasingly important is that the amount of pollution in the home is rapidly increasing. The combustion and cooking fumes alone add great amounts of pollutants and moisture to the air. Add to this the combined vapors of household chemicals, and you have a serious threat to health and safety.

Recent research has definitely established that a wide range of illnesses is due to the daily exposure to smoke, cooking fumes, chemical cleaners, and various sprays. Today's average kitchen and storage cabinets contain about 40 household chemicals. Sprays in the form of deodorants, hair dressings, deodorizers, and polishes keep the air well polluted. These pollutants can cause or aggravate respiratory problems, allergies, skin and eye irritations, dizziness, and even depression.

Where gas appliances are used, they consume large amounts of vital oxygen and deliver toxic pollutants in exchange. Ventilation is vitally important to expel this polluted air and bring in a fresh supply of air.

Cross ventilation is especially important in the bedrooms. Proper ventilation removes warm, moist, and polluted air and is an aid to sleeping comfort.

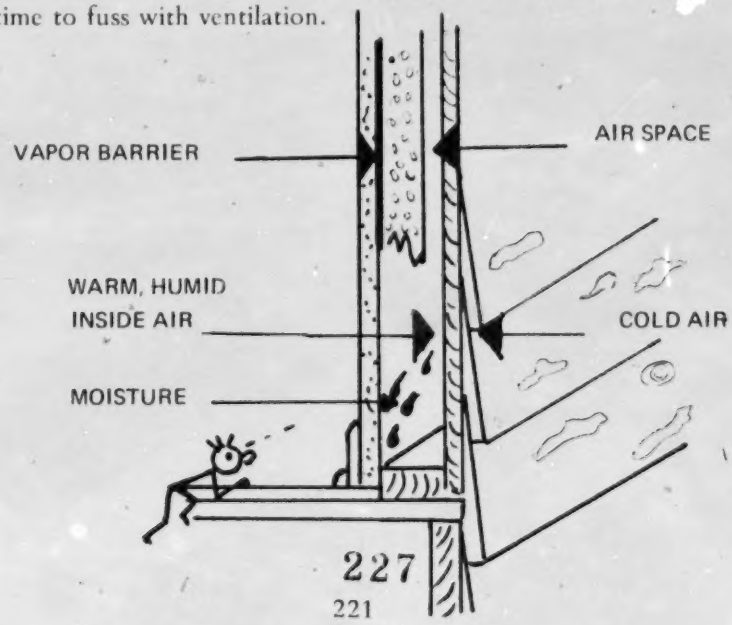
Bathrooms and kitchens should either have natural ventilation from a window or forced ventilation by an exhaust fan. Most building codes require that bathrooms that do not have natural ventilation have an exhaust fan that works automatically when the light switch is on.

Every winter you can read in the newspapers some sad stories of families asphyxiated in their homes. What happened? They were cold, closed up the house tightly, and used a gas or kerosene heater to warm up. But the heater was not properly vented to the out-of-doors — or not vented at all. A fire needs oxygen in order to burn. Man needs oxygen in order to breathe. When the fire used up the oxygen, it went out — and the people were *out* too — permanently.

Even if you are not asphyxiated by a lack of oxygen, poor ventilation may make you feel groggy or headachy.

In addition to protecting *you*, ventilation plays an important role in the appearance, maintenance, and the life of the *structure itself*. Paint peeling and moisture in the walls that cuts down the efficiency of the insulation are only two of the ways that improper ventilation can make your house sick. Add to that mildew, fungus, rot, rust, and condensation, and dampness, and the old homestead may never recover.

Effective insulation and airtight construction are a curse without proper ventilation. In other words, the more perfectly tight the house, the more critical the ventilation. The old barns our grandparents lived in had very few ventilation problems. The fresh air that blew in the doors, windows, and cracks was enough to give you gooseflesh. Then from time to time the cowboy and Indian fights added more ventilation with their rocks, spears, six-shooters, and arrows. Folks were more concerned with inhalation and exhalation, and they had no time to fuss with ventilation.



Windows and Doors **Lesson 2**

Objectives:

1. At the end of this lesson the student will understand the function and importance of windows and doors in ventilation.

2. The student will also realize that the improper selection and placement of windows can defeat the purpose of adequate ventilation and create hazards to safety.

Related Information:

The basic functions of windows are to furnish light and ventilation. This seems like a relatively easy job – but is it? Windows are frequently selected on the basis of price, ease of installation, or how they fit into the architectural scheme.

Many double-hung, casement, awning, and slider windows are so cheaply constructed that it takes superhuman strength to operate them. A mere human often gives up the struggle. As a result, the ventilating ability of the windows is lost – in some cases for the life of the structure.

Windows are frequently placed to provide maximum free-wall space for furniture arrangement. Thus they are kept to a minimum for convenience or economy, and in some cases are completely omitted.

Omission or incorrect placement makes cross ventilation difficult or impossible. Some bow windows and picture windows are selected for beauty alone and have very small or no openings at all. Any combination of these errors produces a structure difficult to ventilate. This can be overcome to a large extent by air conditioning, but without it the windows and doors are the only sources of ventilation.

Poor windows also provide a poor exit in time of an emergency. Some windows when fully opened cannot be used to escape a fire because they are too small. Windows that do not operate properly are extremely hazardous for children or elderly people. To compound the problem, many windows are placed high for furniture arrangement and make no provision for fire or emergencies. Thus window selection is a mighty important decision.

Doors are also an important source of ventilation. The biggest problem with doors is getting them to open and close properly. Sometimes doors give you the reverse of the window problem – more ventilation than you need or want. Frequently doors are so poorly fitted that they automatically ventilate. A door is most times considered as a source of privacy and protection, and ventilation is frequently ignored.

Homework (due in one week). In your visits to friends, neighbors, and kinfolk, see how many windows fall into the "poor" category. Remember, you only have one week, so get going.

The Importance of Attic Louvers **Lesson 3**

Objectives:

1. At the end of this lesson the student will realize that proper louver ventilation can increase comfort and add to the life of the house.

2. The student will also know the critical areas affected by louvers.

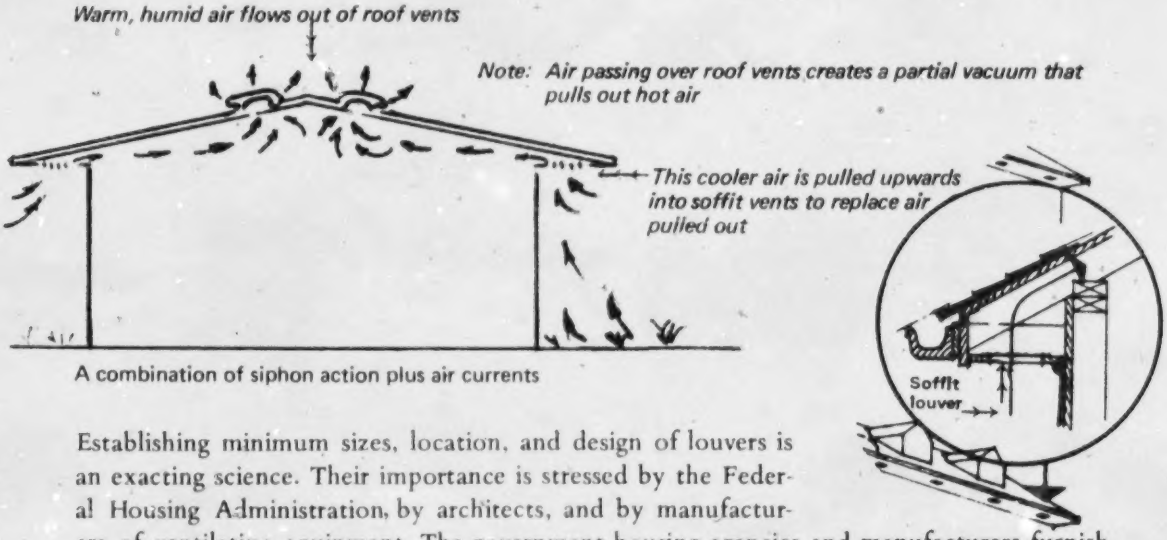
Related Information:

"Louvers" is a fancy name for air vents located in basements, sidewalls, overhangs, roof peaks, and roofs. These ventilators circulate air and remove excess moisture and heat from various parts of the house.

Attic louvers are installed in end walls of a gable roof and provide necessary ventilation for the attic and roof spaces, both winter and summer. For example, summer heat can easily reach temperatures of 130° and more in attic spaces. Attic louvers, properly sized and located, can expel this hot air and appreciably reduce the attic temperature and that of the rooms below.

Air movement through such louvers depends primarily on wind direction and velocity. In simple language this means that if there is no wind, or if the louvers are not facing the wind, the movement of air is zilch.

To overcome this problem, the addition of louvers or vents in the eaves will provide a movement of air even without a wind. This simple correction will result in a difference in temperature between the attic and the outside and provide a movement of air. Then if the wind blows past the eave vents, this will provide an even better movement of air.


Warm, humid air flows out of roof vents
Note: Air passing over roof vents creates a partial vacuum that pulls out hot air
This cooler air is pulled upwards into soffit vents to replace air pulled out
Soffit louver

A combination of siphon action plus air currents

Establishing minimum sizes, location, and design of louvers is an exacting science. Their importance is stressed by the Federal Housing Administration, by architects, and by manufacturers of ventilating equipment. The government housing agencies and manufacturers furnish easy-to-follow guidelines and charts. This valuable and necessary information is frequently neglected by careless builders due to a lack of rigid code requirements.

As a simple example, louvers should provide a minimum free opening of 1/300 of the ceiling area.

Example: House with 1,000 square foot ceiling area:

Louver should equal 1/300 of total area.

Thus: $\frac{1}{300} \times \frac{1000}{1} = \frac{1000}{300}$ or $3\frac{1}{3}$ square feet required.

Test: See how factual this lesson is. Observe how many small ranch-style houses have at least $3\frac{1}{3}$ square feet of free louver space. (Most small ranches are 1,000 square feet or more.)

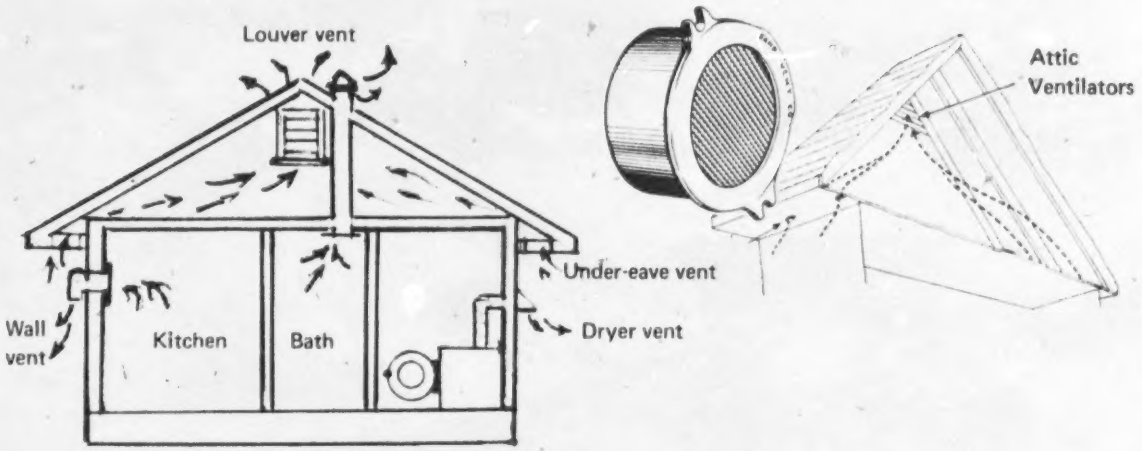
During winter weather a warm attic, plus the heat of the sun, will melt snow on the roof. However, the eaves do not get the extra heat from the attic and this tends to create ice dams in the gutter and roof overhangs. These ice dams can cause water to back up at the eaves and onto the ceiling and walls below.

In a well-built house, a combination of adequate insulation and ventilation can keep attic temperatures low, and melting over the attic space will be reduced. Snow remaining on the roof is a good sign that insulation and ventilation are working.

Correcting Problems With Louvers **Lesson 4**

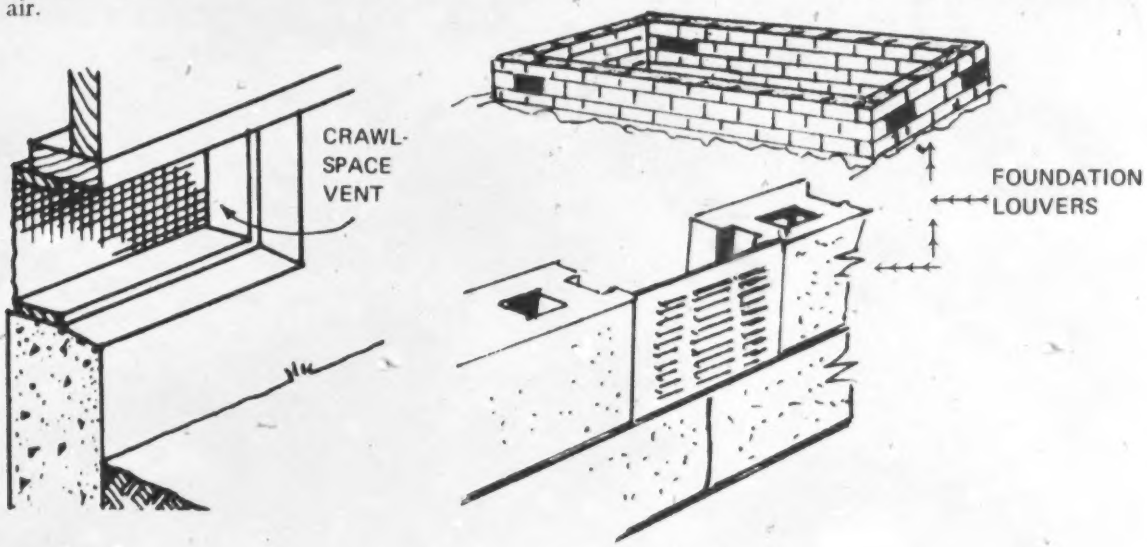
Objective

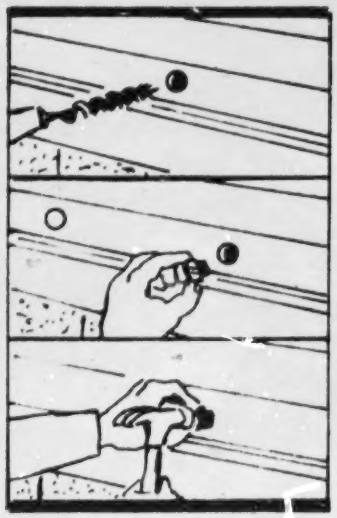
At the end of this lesson the student will understand that louvers can reduce or prevent paint peeling, moisture, decay, and mildew.



Related Information:

A crawl space under a house or porch should be ventilated by louvers to remove moisture. Moisture in these areas is created by moisture rising from the soil or damp masonry slab. This moisture can condense on the wood below the floor and cause decay, mildew, and odors. The ventilators should be installed as high off the ground as possible – one on each corner. Cross ventilation is extremely important to create a movement of air.

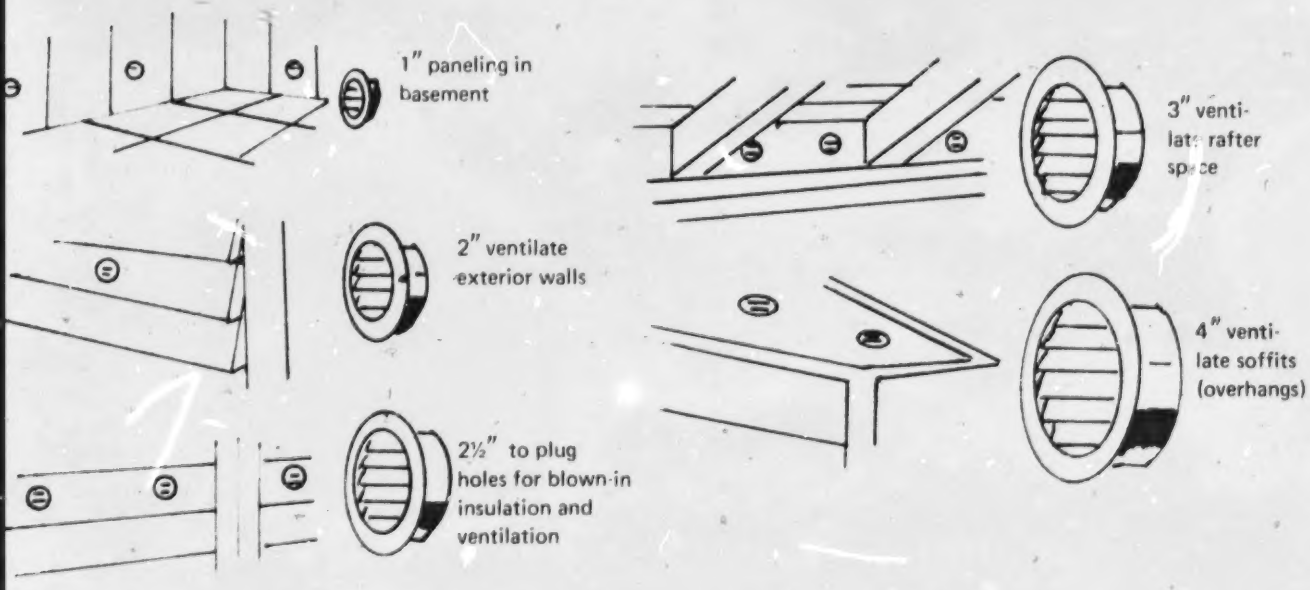




INSTALLING MINIATURE VENTS

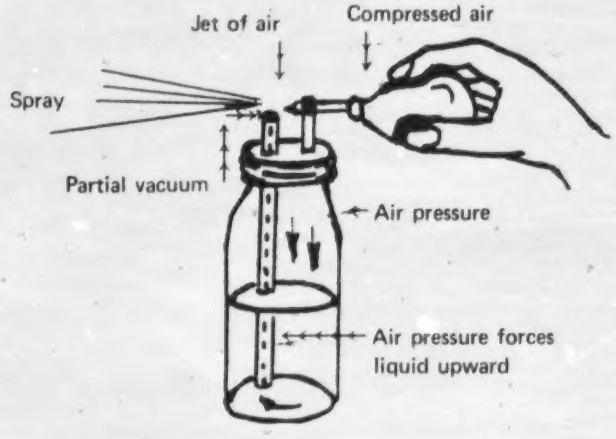
Miniature vents ranging from 1" to 4" can be installed in exterior walls that are subject to paint-peeling and heat-loss. These vents frequently provide the only practical way of releasing dead, damp air from spaces completely enclosed. The miniature vents are installed between the studs, in the rafter spaces of flat roofs, and other hard-to-reach spots. These vents can also be used to ventilate recreation-room walls in a basement.

These vents do increase convection currents within the walls and do cut down the insulating efficiency a little. But you can't have everything. This is the price you must sometimes pay to prevent paint from peeling or wood from rotting. Where a moisture problem exists and you can reach it – you can also ventilate it.


1" paneling in basement
2" ventilate exterior walls
2½" to plug holes for blown-in insulation and ventilation
3" ventilate rafter space
4" ventilate soffits (overhangs)

A FEW USEFUL PLACES FOR MINIATURE LOUVERS

Special roof ventilators can be installed where standard ventilators fail. Any ventilator will work well on hot days, because cooler air pushes the warm air up, and it exits out the nearest opening. However, special roof ventilators don't have to wait for hot days, because they siphon the air out. (See page 224 for illustration.) This special vent is designed so that as air flows past the vent opening it causes the pressure to drop inside the vent collar. Attic air with normal pressure flows into this partial vacuum and is pulled outside. The principle is similar to that in spray guns for spraying paints, perfume, or insecticides. As air speeds over the tube leading to the liquid, it creates a low pressure. This creates a low pressure within the tube as against the extra air pressure outside the tube. This forces the liquid up the tube.



UNIT XIII – INSECT CONTROL

Preventing Termite Infestation **Lesson 1**

Objectives:

1. At the end of this lesson the student will know how location and construction can invite termite infestation.

2. The student will also realize what precautionary measures he can use to prevent termites in construction.

fpft

Related Information:

Termites are marvelous critters. For meat, potatoes, vegetables, and dessert, all they need to eat is *wood*

The termites appearing on the eastern seaboard are called subterranean termites because they ordinarily must have protected access to soil for moisture, or they cannot survive. Thus, the necessity of passing from soil to wood and back again determines how successful termites are going to be in attacking a house. The type of construction and the location can therefore greatly increase the chances of an invasion.

For better appearance, modern homes are built low so as to "hug" the ground. This low, hugging construction, plus slab-construction of homes and additions, really hang out the "welcome mat" for termites. Then when builders convert a beautiful woodland into a development of homes, the termites are the happiest. Building homes in the woodlands is like building woodburger stands for termites.

1. **Construction factors.** All stumps, logs, dead branches, and wood debris should be removed from the site before construction begins. This automatically gets rid of termite colonies already established.

Don't bury scrap lumber, paper, or any other form of wood product in backfilling foundations or in filling for porches, steps, and crawl spaces.

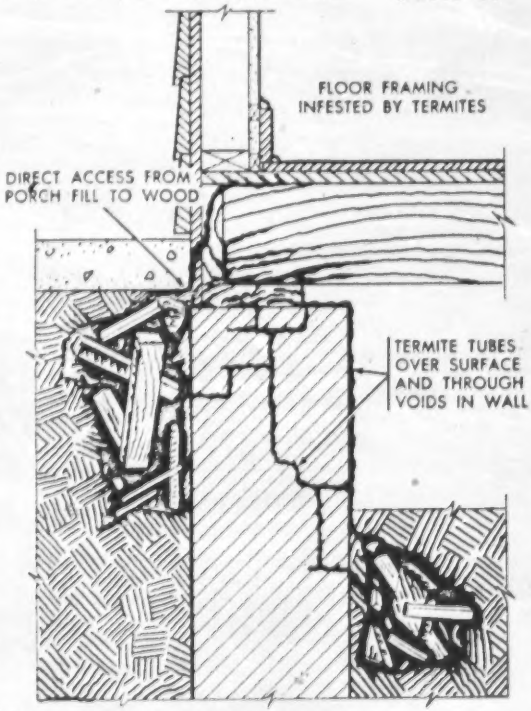
Construction of framing should be at least 6" above ground, and the higher the better. All wood, such as basement windows, outside steps, cellar doors, and door frames should be at least 6" above ground level. The soil should have adequate drainage and not serve as a "water hole" for termites.

Masonry construction should be especially sound to prevent cracks and defects for the entry of termites.

2. **Termite shields.** Metal sheets placed between the foundation and the sills give excellent protection as long as they are properly installed. They should form a continuous strip, covering the top of the masonry wall and extending 2" beyond each edge. This resembles a bread pan turned upside down. The purpose of the shield is to force the termites to come to the surface of the masonry wall. The shields should be constructed of heavy metal, preferably of copper that weighs at least 16 oz. per square foot. Should aluminum be selected, it should be at least 26 gage.

3. **Weak spots.** Earth-filled porches or terraces adjoining a house are especially vulnerable to termite invasion. The colony or colonies often come from buried wood or trash that get buried in the fill dirt. Should you suspect termites, probe areas of the sill, especially around porches, etc. with a sharp ice pick or similar tool. If the pick can be thrust into the wood deeply by simple pressure, then termites or dry rot are present. Remember that termites actually eat the wood and do not leave telltale traces of sawdust.

The telltale signs are mud tunnels or tubes or piles of discarded wings inside or outside the home.


FLOOR FRAMING INFESTED BY TERMITES
DIRECT ACCESS FROM PORCH FILL TO WOOD
TERMITE TUBES OVER SURFACE AND THROUGH VOIDS IN WALL

Subterranean termites infesting building from pieces of wood in soil under building or in dirt fill under porch.

UNIT XIII – INSECT CONTROL

Identification of Insects **Lesson 2**

Objectives:

1. At the end of this lesson the student will know some facts about the nature of termites and will be able to tell the difference between a termite and a flying ant.

2. The student will also gain a knowledge of certain other insects that damage wood structures.

Related Information:

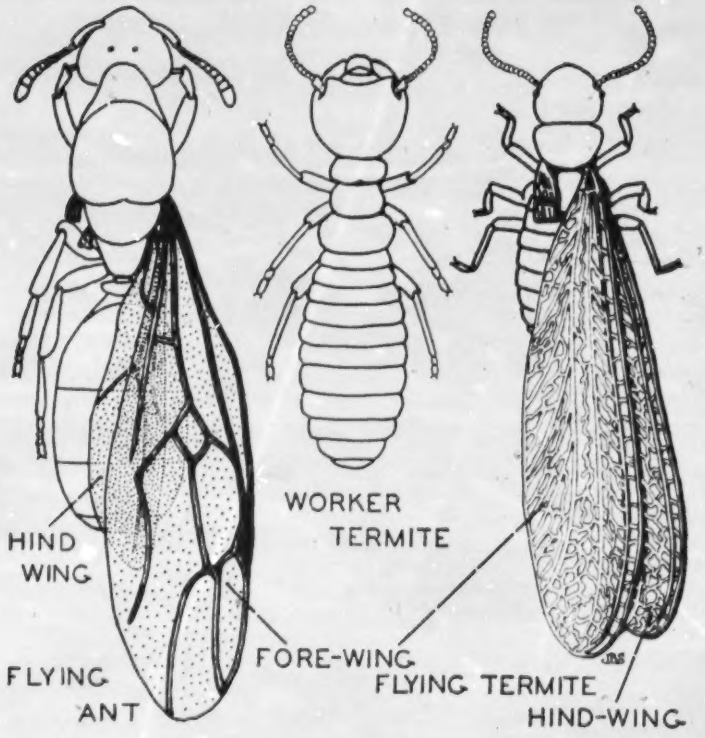
Termites are mean, vicious, beady-eyed, soil-inhabiting insects that feed on wood, paper, and similar cellulose products. This lesson is primarily concerned with their wood-snapping activities, because wood is high on their menu list. Their threat to paper products such as test papers, worksheets, and textbooks is minor – due to the heroic efforts of teachers around the world. Teachers for years have devoted evenings, weekend, and vacations to swatting and spraying, and by now have the paper and book threat licked. Their expert knowledge gained from this experience is set forth in this lesson so that you can protect your homestead.

Termites, like ants, are *social* insects. They live in colonies which often consist of many thousands of hungry kinfolk. They consist of three groups: the reproductive adults – males and females, the soldiers that protect the colony, and the soft-bodied wingless workers that provide the food.

The reproductive males and females have wings, and they use them to locate new colonies – for example, your home. Therefore, the sudden appearance of winged termites inside or outside your house on some fine spring day is bad news. Don't panic and sell the house or quit school but put your head to work and beat the critters.

The rest of the colony consists of the protective forms, or soldiers, and the workers, vocationally trained termites that construct tunnels and tubes. The workers also double as cooks, providing themselves and the colony with food in the form of cellulose.

If you were to break open a termite-infested piece of wood, you would find the young, the workers, the soldiers, and some wingless reproductive forms. They would be white or cream-colored, soft, and blind. They are sensitive to strong sunlight and exposure to air and hence would die soon. That is why they never leave the protection of their tunnels in soil, mud, or wood: They have a beautiful subway system and don't need any light.



The identification of termites is just as important as the treatment. Winged ants are frequently mistaken for winged termites, and so it pays to study the accompanying drawing..

The winged termites soon drop their wings, but winged ants do not. Note that winged ants have a narrow, wasp-like waist, while the termite has a full, thick waist and bead-like antennae. The flying ant is harmless, but that termite is a rough, tough, gnawing critter – so get your identification down pat.

Friend or foe?

Specimens of any insects may be sent to your county agricultural agent for proper identification. Many states rank termites as the most expensive single species of insect and are willing to help you with identification and information on treatment.

Some other insects that are fond of snapping at your timbers are carpenter ants and powderpost beetles. The carpenter ants are similar in appearance and colony habits to the termites, but have a different life-style. There are reproductive forms, and two sets of workers. They also tunnel into wood, but only to provide a home for themselves and their young. They do not eat the wood but remove only enough to house themselves. Small piles of discarded sawdust or particles indicate carpenter ants but never termites.

Powderpost beetles make real fine holes in wood, and their tunnels are packed with a fine, powdery wood dust. They are especially fond of old homes, and the powdery dust sifts through, making little piles. They like to snap away at roof girders and joists and other high and dry stuff, whereas termites like the sills and joists near the soil, where there is moisture.